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REPORT OF
**TWENTY-THIRD ANNUAL
DATE GROWERS' INSTITUTE**

APRIL 27, 1946



HELD IN
COACHELLA VALLEY
CALIFORNIA

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The Date Institute, a non-profit educational organization devoted to furthering the knowledge of date growing, is now in its twenty-third year. Published copies of the papers given at this Institute will be obtainable from the secretary at a later date. Copies of past Institute reports may also be obtained from the secretary.

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23rd Annual Date Growers' Institute

Saturday, April 27, 1946

Chairman, Morning Session: S. H. Cameron, Head of the Division of Horticulture, U. C. L. A.

Chairman, Afternoon Session: Dr. Walter Reuther, U. S. Government Date Garden

THE EFFECT OF TEMPERATURE AND BAGGING ON FRUIT SET OF DATES

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Growers' experiences over a period of years have indicated that there is considerable variation from season to season in set of date fruit, and that some varieties are more likely to produce an unsatisfactory set of fruit than others. Of the important commercial varieties *Khadrawy* seems to be more likely to produce an unsatisfactory set than any other¹. However, even with the extensively planted *Deglet Noor* variety, poor set has occasionally been an important yield-reducing factor. According to notes and records on file at the U. S. Date Garden, the 1935 and 1945 seasons were the only ones during the past 20 years in which poor set was of widespread occurrence in many *Deglet Noor* plantings in all parts of the Coachella Valley. Of course, nearly every season a few *Deglet Noor* growers experience some loss due to unsatisfactory set. It is the purpose of this paper to present some data which seem to provide a partial explanation of the seasonal and varietal differences in fruit set which have been experienced by growers, and to suggest methods for improving set during unfavorable weather conditions.

Temperature and Fruit Set

The data shown in Table 1 were obtained in connection with studies on the effect of bagging and certain other treatments on set of fruit. The mean percentages of fruit set were obtained from the pollinated, but unbagged control half of flower clusters which were pollinated in a manner similar to standard commercial practice. The details of the technique used will be described later. The corresponding temperature data were obtained from thermograph charts recorded by an instrument located in a standard Weather Bu-

rean type of shelter located on the grounds of the U. S. Date Garden. The relationship between percentage of set and the total heat (degree-hours of heat above 60° F.) which prevailed in the week following the date of pollination, was highly significant statistically, but the degree of correlation obtained indicates that other factors are involved also. The principal limitations of these data are the lack of a sufficient number of observations during the four-year period, and an insufficient proportion of observations in the low heat range below 750 degree-hours. Nevertheless, the data strongly suggest that the prevailing temperature condition is one of the factors that affect set of fruit.

Statistical evaluations were made of the relations between numerous indices of windiness and set level during the 1943, 1944, and 1945 seasons. None of the indices used was correlated significantly with set. The highest correlation obtained between windiness and set was obtained with the index presented in Table 1. In addition, it was determined that there was no significant relation between the heat index presented in Table 1, and a comparable index of total wind movement in the seven-day period following the date of pollination. Undoubtedly, carefully controlled experiments will be required to establish definitely the effect of windiness on set. The indices obtained from the wind data available did not take into account the possible effect of timing, temperature level, humidity, and the period of delay between the time the spathe opened and exposed the flower strands, and the time of pollination. This interval varied in these experiments from a few hours to two days. It seems logical that windiness would effect the rate of dehydration of stigmas, and hence, the

receptivity of these flowers to pollen.

The data summarized in Figure 1 show the prevailing temperature conditions during the 1943, 1944, 1945, and 1946 seasons for the period February 10 through March 31, the portion of the pollination season in which cool weather is likely to occur. Similar data are also presented for the 1935 season. The 1935, like the 1945 season, was characterized by widespread poor set of *Deglet Noor* and other varieties in many plantings in the Coachella Valley. Each point on these curves represents the total degree-hours above 60° F. which occurred in the seven-day period following the corresponding date indicated along the base line. Note the similarity of the prevailing temperature conditions in the 1935 and 1945 seasons. Note also that the 1944 season was very cold in February. Flower clusters pollinated during this period probably produced an unsatisfactory set (Table 2).

The data presented in Table 2 were obtained from certain *Deglet Noor* growers who keep records of the number of blooms pollinated each day. From these records it was calculated what percentage of blooms were pollinated on dates followed by cool weather (less than 750 degree-hours of heat in the seven-day period following pollination). It may be seen that there is considerable variation in the percentage of blooms opening and pollinated during cool weather among the three plantings in any given season, and this may explain in part the wide differences in set which occur in different plantings in a given season. It will be noted also that with the exception of orchard S there is some correlation between the percentage of blooms pollinated during cool weather and the prevalence of unpollinated fruit in the planting.

(1) Russell, R., Report of Date Growers Inst. 8:3-5—1931.

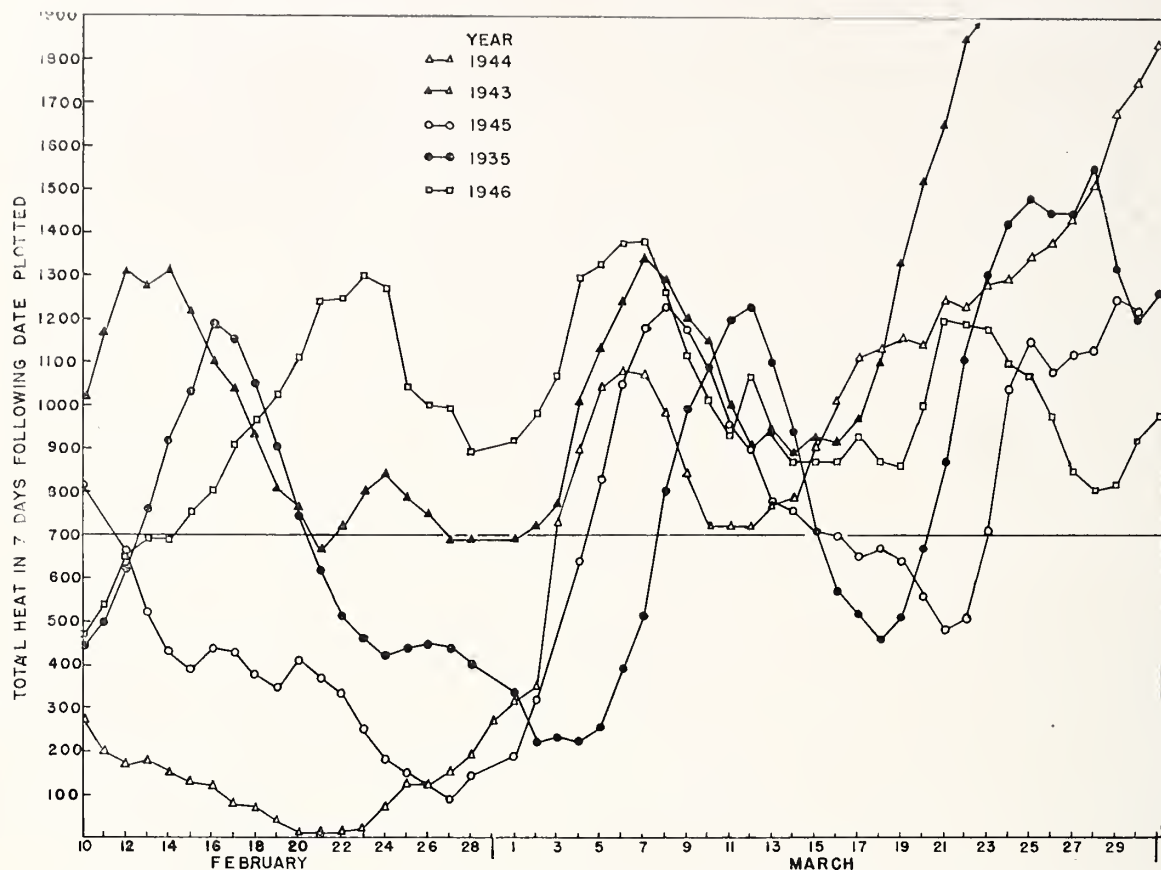


Figure 1. A comparison of the prevailing temperature conditions in five pollination seasons. Heat, expressed as the total number of degree-hours above 60° F. in a seven-day period, is plotted along the vertical axis. The date on which the seven-day period begins is plotted along the horizontal axis.

It is well known that the Khadrawy variety begins blooming 10 to 15 days before the Deglet Noor variety. This may account in part for the tendency of this variety to produce a less satisfactory set of fruit, on the average, than later-blooming varieties such as Deglet Noor, Halawy, and Zahidi. In most seasons a greater percentage of blooms would open and be ready for pollination during cool weather than would be the case with later-blooming varieties. Many growers have observed that the most exposed palms on the outside south and west rows of a planting tend to bloom sooner than the rest of the planting, and also tend to produce the most bunches with unsatisfactory sets of fruit. Observations have repeatedly indicated that the upper bunches, which emerge first, tend to have the most unpollinated fruit. All of these data and observations suggest that the cool weather which is likely to occur during the first half of the pollination season tends to reduce set of fruit. However, there are enough exceptions and inconsistencies to indicate strongly that several other important factors are involved.

The Effect of Bagging on Set of Fruit

For many years pollination ex-

periments of various kinds have been carried on at the U. S. Date Garden¹. In nearly all of these experiments, paper bags were placed over all or various portions of the flower strands to prevent contamination from extraneous air-blown pollen. It was often noted in these experiments that enclosing the flowers in a bag prevented the flower stigmas from drying out and turning dark so rapidly as those not enclosed in a bag. A few growers have in the past used paper bags to cover flower strands after pollination with a view to keeping the pollen from being washed off during rainy weather, or blown away during windy periods. With this background in mind, a series of experiments were begun in 1942 with the Khadrawy variety to determine the effect of bagging on set. The method used was quite simple. At various dates throughout the season a series of blooms² were pollinated in the regular way, not more than two days after the enclosing spathe split open, by dusting copiously with pollen-impreg-

nated cotton balls. Then the flower strands were divided into two equal groups, a brown paper bag placed over one half, and the other half allowed to remain exposed in the normal manner. Identification tags were attached to each of these experimental blooms. The bags were removed when the bunches were thinned and tied down and set counts were made during the last two weeks in May. The percentage of set was determined on each half-bunch by selecting at random one inside and two outside strands, counting the total number of flower scars, unpollinated (undeveloped) and pollinated fruit, and calculating the percentage of set as the ratio of pollinated fruit to the total number of flowers that were present initially on the strands. The total number of flowers per strand ranged between 35 and 65, so that in the great majority of cases between 100 and 200 flowers were considered in determining the percentage of set on three strands in each treatment on a given bloom. The data obtained in this manner during three seasons are summarized in Table 3. It will be noted that set was improved by bagging only on certain pollination dates. In general, there was a progressive increase in set improvement due to bagging as the percentage

(1) Nixon, R.W., Report of Date Growers Inst. 11:9-11-1934. Aldrich, W. W., and C. L. Crawford, Report of Date Growers Inst. 18:5-1941.

(2) The date growers of the Southwest commonly call the entire date inflorescence a "bloom". Hence the term "bloom" as used in this paper refers to the entire inflorescence, which is a branched spadix.

Table 1. The Relation of Percentage of Khadrawy Fruit Set to Temperature Conditions Prevailing During the Week Following the Date of Pollination.

Date of Pollination	Number of Inflorescences Observed	Date Set Counts Made	Mean Percentage Set	Heat* (Degree-hrs. above 60° F.)	Index** of total wind Movement
Feb. 16, 1942	10	May 19	23.1	250	
Feb. 16, 1943	10	May 10	62.0	1110	20
	10		61.9	1040	19
	12	to	54.3	810	15
	19		54.3	720	19
Mar. 11	21	May 19	62.1	1040	24
	15		58.7	930	36
	7		61.4	910	31
Mar. 7, 1944	15	May 22	52.2	1070	14
	26		48.3	720	22
	8	to	51.3	790	13
	20		63.9	1140	24
	15	May 26	67.2	1230	9
	15		70.7	1350	14
	17		67.8	1460	11
Mar. 9, 1945	9	May 15	42.9	1180	13
	23		40.7	780	30
	35	to	36.8	650	20
	18		46.4	1040	22
	40	May 24	48.7	1120	21
Apr. 19	10		70.1	2980	20

* Heat is expressed as total degree-hours above 60° F. in the 7-day period following the date of pollination. This is determined by measuring the area under the daily thermograph temperature curves (using 60° F. as the base line) by means of a planimeter, and multiplying by the appropriate factor to convert to degree-hours.

** The sum of the mean wind velocities in the 3-day period following the date of pollination. The mean velocity was determined by averaging hourly readings taken by a local airway weather station.

STATISTICAL CALCULATIONS:

1. Coefficient of correlation (r) between percentage set and total heat is 0.589, and (r) required for significance at .01 level with 21 pairs of observations is 0.537. Thus there is a highly significant correlation between the percentage of fruit set and total heat in the seven-day period following the date of pollination.
2. The variance in percentage of fruit set among the different dates of pollination is significantly greater than the variance among blooms pollinated on the same date. In other words, there is a highly significant effect of date of pollination on the percentage of fruit set.
3. The standard deviation of the mean percentage of set obtained from 10 observations is about 3.2%, from 20 observations about 2.2%, and from 30 about 1.8%.
4. Coefficient of correlation (r) between percentage set and the wind index is -.141. This is not significant.

Table 2. Effect of Temperature on Fruit Set of Deglet Noor Dates in the Coachella Valley.

Garden	Location	Year	Percentage of blooms pollinated during cool weather*	Fruit Set**
C	Indio Hgts.	1944	11.0	Good
		1945	32.7	Poor
S	Indian Wells	1943	8.8	Good
		1944	2.1	Good
		1945	26.2	Good
B	Oasis	1943	6.9	Good
		1944	21.9	Poor
		1945	32.4	Poor

* The percentage of blooms that were pollinated on dates that were followed by less than 750 degree-hours of heat above 60° F. in the seven-day period following pollination.

** According to the owner's or manager's observations.

of set on the unbagged halves of the bunches decreased.

The data presented for the Dayri variety seem to be inconsistent. In the 1943 season, when the level of set of the Dayri variety without bags was quite high, bagging actually decreased set; in the 1944 season when the level of set without bags was considerably lower, bagging in-

creased set appreciably. However, these results are actually quite consistent with the trend of the Khadrawy data. Set on the unbagged half of the bunch was related to the improvement in set due to bagging the other (bagged) half for all the individual blooms studied during 1943 and 1944. Statistical analysis shows that, in the main, bagging

actually decreased set when the level of set on the unbagged strands rose above 70 percent. As the level of set on unbagged strands fell below 70 percent there was a progressive increase in the improvement of set due to bagging. This relationship is best illustrated by the numerical values presented in Table 4. These data (Tables 3 and 4) show, then, that the more unfavorably the conditions are for set on exposed blooms, the more the set is likely to be improved by enclosing the bloom in a paper bag after pollination.

The Relation of Initial Set to Drop and Potential Yield

The final potential yield of any given bunch of dates probably is not exactly proportional to the level of set obtained in the latter part of May. For example, if a 70 percent set is considered ideal, then a 35 percent set will not necessarily result exactly in a 50 percent reduction in the potential weight of ripe fruit produced by the bunch. Thinning experiments¹ have shown that reducing the number of fruits per strand results in larger fruit. On the other hand, heavy thinning of strands also increases the proportion of fruits that drop in the three-and-one-half month period from June 1 until ripening begins². Similarly, the lower the percentage of flowers setting fruit (as determined during the latter part of May or the first part of June), the greater proportion of these that are likely to drop before ripening begins. This relationship is shown by the data presented in Table 5. Thus it may be seen that as the number of pollinated fruits per strand is reduced either by poor pollination or by thinning, the susceptibility of the remaining fruits to shedding before ripening begins is increased. For example, using the 1935 data as a basis for prediction, a bunch of dates moderately thinned at the time of pollination may have around 1500 flowers. If 70 percent of these set fruit, the number of developed fruits on June 1 would be 1050. By the middle of September, 14.6 percent of these may be expected to fall off (Table 5), leaving 897 fruits at the beginning of ripening. If only 35 percent of the flowers set fruit on another otherwise comparable bunch, the number of developed fruits would be 525. By the middle of September, 27.0 percent of these may be expected to fall off, leaving only 383 fruits on the bunch at the beginning of ripening. Thinning ex-

(1) Nixon, R. W., Proc. Amer. Soc. for Hort. Sci. 41:85-92-1942.

(2) Nixon, R. W., Report of Date Growers' Inst. 13:6-8-1936.

Table 3. The Effect of Bagging on Set of Date Fruit.

Date of Pollination	Variety	Number of Blooms Observed	Date Set Counts Made	Treatment (mean % flowers set)		Increase Due to Bagging (mean difference) ¹
Feb. 16, 1942	Khadravy	10	May 19	23.1	33.7	+ 10.6**
Feb. 16, 1943	Khadravy	10		62.0	61.1	— 0.9
17		10	May 10	61.9	66.8	+ 4.9*
19		12		54.3	65.2	+ 10.9**
22		19	to	54.3	67.4	+ 13.1**
Mar. 11, 1943		21		62.1	63.0	+ 0.9
15		15	May 19	58.7	62.9	+ 4.2*
16		7		61.4	61.3	— 0.1
Total, 1943	Khadravy	94		58.9	64.2	+ 5.3**
Mar. 7, 1944	Khadravy	15		52.2	62.1	+ 9.9**
10		26	May 22	48.3	58.5	+ 10.2**
14		8		51.3	59.5	+ 8.2**
18		20	to	63.9	72.2	+ 8.3**
22		15		67.2	67.8	+ 0.6
25		15	May 26	70.7	72.3	+ 1.6
27		17		67.8	69.8	+ 2.0
Total, 1944		116		59.9	66.0	+ 6.1**
Total, 1943	Dayri	43		76.5	73.1	— 3.4**
Total, 1944	Dayri	20		47.3	53.9	+ 6.6**

(1) Significance determined by Student's "t" method. Two asterisks ** after the mean difference indicates significance at the .01 level, and one asterisk *, significance at the .05 level.

Table 4. The Relation¹ of Percentage of Set on Unbagged Flower Strands to Percentage of Set on Bagged Flower Strands. (1943 and 1944 Khadravy data combined, calculated for six percentage levels for unbagged strands).

A. Set, UNBAGGED:.....	30	40	50	60	70	80
B. Increase due to bagging:.....	24	18	12	6	0	—6
C. Set, BAGGED (A + B):.....	54	58	62	66	70	74

A. The percentage of flowers setting pollinated fruit on unbagged strands.

B. The corresponding average increase in percentage of flowers setting fruit which may be expected (based on 1943 and 1944 experience) to result from enclosing the flower strands in bags.

C. The corresponding average percentage of flowers setting pollinated fruit on bagged strands.

(1) This relationship was obtained by combining all of the 1943 and 1944 data, and plotting individually the increase in percentage of flowers setting fruit due to bagging against the percentage of flowers setting fruit on the unbagged half of the bloom for each of the 210 blooms observed in the two seasons. Statistical treatment of these data showed that the coefficient of correlation was -0.651 , indicating a highly significant inverse relationship. The comparative set percentages presented above were obtained by making six substitutions in the calculated regression equation relating increase in set on bagged strands to set on corresponding unbagged strands. The standard deviation of the increase in percentage of flowers setting fruit as a result of bagging was 8.26. All set determinations were made in the latter part of May of each year.

periments¹ suggest that the strands setting only 35 percent of flowers would develop, on vigorous palms, about 20 to 25 percent larger fruit than would strands setting 70 percent of flowers. Hence, the bunch with 70 percent initial set, according to these calculations and assumptions, would be expected to yield (at 45 dates per pound) about 20 pounds of dates, and the bunch with the 35 percent initial set (at 36 dates per pound), about 10.6 pounds of dates. Thus the actual reduction in potential yield is somewhat less than 50 percent. These calculations are, of course, based on very limited data and embody certain assumptions. Without doubt,

the percentage of drop before ripening, and the increase in size due to reduced set would vary considerably with variety, season, cultural practices, and other factors. Nevertheless, the broad principle is clear—the potential yield of a given bunch is roughly proportional to the initial-set level. Thus it follows that any improvement in initial set produced by bagging a given bunch is likely to be associated with an almost comparable improvement in the potential yield of that bunch. It follows, also, that if the overall initial set level for the season can be increased from 60 percent to 65 percent by bagging, an increase of 5 percentage points, or about 8 percent increase in number of fruits setting, the potential yield of the entire orchard also should be increased about 8 percent.

Discussion

Evidence has been presented showing that under certain conditions enclosing the flower strands in a brown paper bag after pollination improved fruit set. Just why bagging has this effect is not definitely known. However, there is some evidence suggesting that cool temperatures following pollination limit fruit set. This suggests that set improvement due to bagging is caused, in part at least, by the tendency of the bag to increase the temperature of the bloom it encloses. Temperature measurements made by inserting thermometers into the interior of flower clusters enclosed in bags fully exposed to sunlight indicated that temperature was increased 5 to 15 degrees F. above the interior temperature of flower clusters not enclosed in bags, but exposed in a comparable manner. In full shade, the temperature in flower clusters was not appreciably affected by enclosure in a paper bag. In partial shade bagging produced an effect on temperature intermediate between full sunlight and full shade.

Other obvious effects of bagging are to increase humidity around the flowers and practically to eliminate air currents. Observations have indicated that the stigmas (the part of the flower on which the pollen grains germinate) of flowers under bags remain fresh and crisp much longer than those on exposed flowers, which at times have been observed to dry out and turn brown within 3 or 4 days after the spathe opens. Thus the major effects of bagging probably are to increase temperature and prolong the period of receptivity of the flower stigmas. Increasing temperature without doubt hastens pollen germination and growth. Laboratory studies have shown that at temperatures of 60° F. or below, date pollen germinates very slowly. The rate of germination and pollen tube growth increases rapidly up to about 95° F. For example, in one series of tests, 20 percent of the pollen grains had germinated after 2½ hours at 85° F., but this level of germination was not reached until 29 hours at 60° F. In addition, bagging may lessen the dissipation of pollen by wind or rain, and shield the stigmas from dust particles which may compete with pollen for space on the stigmatic surface. However, it was not possible to show any statistical relation between set and an index of windiness related to total wind movement or maximum velocity.

In the 1943 and 1944 seasons, when set of the Khadravy variety in our experimental block would be considered satisfactory by the usual commercial standards, bagging pro-

(1) Nixon, R. W., Report of Date Growers' Inst. 13:6-8—1936.

Table 5. The Relation¹ of the Percentage of Drop Before Ripening to the Initial Percentage of Set. (Deglet Noor data², 1935, calculated for six percentage levels of set on June 1).

A. Set, June 1:.....	30.0	40.0	50.0	60.0	70.0	80.0
B. Remaining, Sept. 18:.....	21.4	29.9	32.2	49.1	59.8	71.1
C. Drop, 6/1 to 9/18:.....	28.7	25.2	21.6	18.1	14.6	11.1

A. The percentages of FLOWERS developing pollinated fruit when counted on June 1.

B. The corresponding average percentages of FLOWERS developing pollinated fruit which might be expected to persist until the beginning of ripening, based on the 1935 experience.

C. The corresponding percentages of FRUIT [100 (A-B/A)] which were set on June 1, but which may be expected to drop during the period from June 1, until the beginning of ripening.

(1) This relationship was determined by making set counts on June 1 on 196 Deglet Noor date bunches, then making a subsequent count on Sept. 18 to determine the number of pollinated fruit that had dropped during this 3½ month period. The percentages of FLOWERS set in June for each of the 196 bunches were then plotted individually against the percentages of pollinated FRUIT set in June that dropped before the beginning of ripening. The correlation coefficient for the relationship between these two values was -0.458 (0.181 required for significance at the .01 level) indicating a highly significant negative correlation between initial set and subsequent drop. The values presented in the table above are mean values that were obtained by substitution in the calculated regression equation relating drop (C) and initial set (A). The standard deviation of (C) in relation to (A) was 8.95.

(2) From data obtained in 1935 by R. W. Nixon and C. L. Crawford in connection with same thinning studies. Only the data from light and moderate treatments were used.

duced an over-all improvement in set of 5 to 6 percentage points for the first two-thirds of the season. Evidence has been presented which indicates that this may be expected to result in a corresponding improvement in final yield. Thus it is suggested that bagging may more than pay for itself even in seasons reasonably favorable for good set, and probably would be very profitable in seasons unfavorable for fruit set.

The above discussion naturally brings up the question as to what constitutes a good set. This question cannot be answered with precision as yet, but judging from the experience of growers and observations, the optimum level of set (as determined in the latter part of May or the first part of June) for maximum yield and fruit quality is somewhere between 60 and 70 percent for most varieties. However, data and observations indicate that casual inspection of a bunch at the time it is tied down would not indicate to the observer whether the level of set was high or low unless the condition was extreme. At 80 percent set or above the fruits will be visibly thick and crowded on the strand. At 40 percent set or below, the fruits will be visibly sparse, and numerous unpollinated fruits will be

observed. Differences in set level between 50 and 70 percent are not so readily evaluated by casual inspection. In this range relatively few unpollinated fruit persist and develop and the difference in density on the strand is not readily detected except by counting a large number of strands. Thus two palms, one having 50 percent average set, and the other having 60 percent average set (20 percent more fruit), but otherwise comparable, may differ in yield by almost 20 percent due to differences in set which would not ordinarily be noticed even by a careful observer.

These studies concerning the effect of bagging on set have been confined to Khadrawy and Dayri varieties that most frequently give trouble with set. However, there is no reason to believe that bags would not be potentially as effective in increasing set on the Deglet Noor variety during an unfavorable season. The few growers who used bloom bags on Deglet Noor during the 1945 season reported good results, and comparatively few unpollinated dates.

Conclusions

The evidence and observations summarized in this study suggest

that bagging of blooms after pollination is likely to increase fruit set every year sufficiently to pay for the slight additional cost of this practice, and has not been observed to do any damage. In some seasons, when temperature or other factors are exceptionally unfavorable for set, bagging is likely to improve set materially on those bunches pollinated on dates followed by unfavorable weather conditions.

The following suggestions are made in the light of our present limited data and experience, and doubtless will be subject to modifications as we gain more experience and data on the value of bagging. Long brown paper bags (of the type used for enclosing bottles or French bread) should be placed over all of the bunches that emerge during the first half to two-thirds of the pollination season. Bags made of paper impregnated with materials that increase translucence (such as wax) or volatile chemicals or dark-colored dyes should not be used. The brown paper bags should be secured in some manner to prevent the wind from blowing them off. They may be removed after they have been on about 15 days, but may be left on until May when the bunches are tied down, if desired. Since pollen germination and fertilization of the embryo probably take place during a 7 to 10-day period after pollination, it is advisable to use bags on all of the early blooms as they emerge. Some growers this past season used bags only when the weather conditions on that particular day seemed unfavorable. Since it is not possible to predict the weather for a week to 10 days in advance, it is wise to use bags on all blooms during the first half to two-thirds of the pollination season, as an insurance measure.

In conclusion, it may be well to emphasize that bagging the bunches after pollination in no way reduces the need for care in collection, handling, and application of pollen. Neither does it reduce the importance of avoiding, as much as possible, delay in pollination of opened blooms. Bagging should not be regarded as positive insurance against poor set.

STATUS OF THE OMPHALIA ROOT ROT SURVEY

by Glenn KenKnight and L. A. Waitzinger

The Omphalia Date Root Rot Survey now has been in progress for about six months. The purpose of the survey is to determine the presence or absence of Omphalia root rot in all date palms in California. Date orchards will be charted and the location of weak palms noted. Root samples will be taken from weak palms and from every fifth palm where the palms appear healthy. As nearly as possible the exact outline of infested areas will be charted in orchards where the disease occurs. This will make it possible for growers with only a few diseased palms to eradicate the disease from their orchards. At present young orchards with available offshoots are being surveyed in an effort to disclose sources of Omphalia-free offshoots. This is of particular importance now while the date industry is expanding in the Coachella Valley.

In taking root samples a hole is dug 8 or 12 inches from the base of a palm to a depth of about two feet. The roots obtained are taken to the laboratory. Plantings are made on agar plates of rotted and partially rotted roots and small roots with dead tips. The plates are incubated for about a week. Any fungus colonies that are snow white and otherwise resemble Omphalia (1), both to the unaided eye and under a high power microscope, are tested to determine whether they will cause root rot on young date seedlings in the greenhouse. Those that do cause root rot are regarded as Omphalia.

On orchard charts normal palms are represented by a dot (.), weak palms by a line (/), and very weak palms by a cross (X). Palms with one or more dead offshoots are marked with a z. Other symbols are employed to indicate palms that differ in variety or age from the rest of the stand. Palms from which root samples have been taken are encircled. In Table I a portion of the chart for Orchard 14 is reproduced.

Lack of vigor in a date palm is regarded as a symptom of Omphalia root rot. The organism is not obtained from root samples from all palms marked (X) even in Omphalia infested areas of orchards. Diseased roots, if present, can be missed in the sampling process. When one side of a palm has more dead leaves or more slender fruit stalks than the other sides, the

Table I. Extract from Chart of Orchard Number 14.

	1	2	3	4	5	6	7	8	9	10	11
1	/	.	.	.	(/)	/	.	(.)	.	.	.
2	(x)	r	.	.	/	/	.	.	.	.	.
3	x	x	/	.	r	/	.	.	.	(/)	.
4	/	.	/	.	.	(x)	/	.	/	.	.
5	/	.	/	/	/	(x)	/	.	/	/	.
6	/	/	/	.	/	/	/	.	/	.	(/)
7	/	x	/	.	.	.	/	/	.	.	.
8	/	(x)	.	r	.	.	.	/	.	.	.
9	.	s	.	.	(z)	.	.	.	/	(/)	.

. = normal palm
 / = weak palm
 x = very weak palm
 () = root sample negative
 (x) = Omphalia isolated
 z = palm with dead offshoot
 r = replanted
 s = seedling (others all Deglet Naar)

Table II. Relation of Condition of Palm and Side Sampled to Isolation of Omphalia.

		Number of Samples					
		— Condition of Palm —					
SIDE	RESULT	.	/	x	z	sum	percent
North	Omphalia	4	9	2	2	17	27.9
	negative	29	5	7	3	44	
East	Omphalia	5	2	4	2	13	21.0
	negative	29	12	6	2	49	
South	Omphalia	0	4	4	0	8	11.1
	negative	34	19	7	4	64	
West	Omphalia	1	3	3	1	8	13.6
	negative	33	14	1	3	51	
sum		135	68	34	17	254	
%	Omphalia	7.4	26.5	38.2	29.4		18.1

Table III. Considering Only Palms Graded as (.) or (/)

		Number of Samples			
		North	East	South	West
Omphalia	.....	14	7	4	4
negative	.....	34	41	53	47
Percent Omphalia	..	27.7	14.6	7.0	8.0

root sample is taken on that side. This does not apply to palms marked (.) and often not to palms (/). Data from 11 orchards in which Omphalia root rot was found is summarized in Table II. The data include only samples taken from Deglet Noor palms. They do not include samples taken on more than one side or those taken on the NE, NW, SE, or SW. It will be noted that Omphalia was isolated from 38.2, 26.5, and 7.4 percent of palms

graded (X), (/), and (.) respectively. Palms with dead offshoots gave Omphalia more often than palms which appeared to have mild secondary symptoms, and in some orchards more often than palms with severe secondary symptoms. This does not necessarily indicate that Omphalia killed the offshoots. The fungus is found in decaying roots. These are more abundant on weak than on normal palms.

Samples taken on the north side

of palms (Table II) yielded *Omphalia* slightly more often than samples taken on the east, and twice as often as samples taken on the south or west. This is not true for palms with secondary symptoms. If one considers only palms marked (.) or (/) it will be seen that samples taken on the north, east, south, and west yielded *Omphalia* in 27.7, 14.6, 7.0, and 8.0 percent of the cases respectively. The superiority of samples taken from the north has been so consistent throughout the survey thus far, that there is scarcely a remote possibility that it is due to chance.

In orchards like No. 14 (Table I) where *Omphalia* is obtained rather frequently from root samples, it would seem impractical to attempt to outline infested areas. More samples would probably produce more *Omphalia* isolates. In orchards where isolated palms appear to have *Omphalia*, root samples are taken

from all weak palms, and from palms two palm spaces (about 60 ft.) from infected palms. If these prove negative, two samples are taken from each palm within one palm space of infected palms. Thus, in orchards where *Omphalia* is found, the men taking root samples must return again and again to the orchard until the infested areas are actually outlined or it becomes apparent that *Omphalia* is so prevalent in the orchard that it would be unsafe to assume that any part of it were wholly free from the disease.

Up to April 15, 1946 about 600 acres of date orchards had been charted. One or more root samples had been taken from 33 properties scattered from Cathedral City to Oasis. Root samples were taken from 453 palms. Of these 56 yielded *Omphalia* isolates. *Omphalia* root rot was found on thirteen properties not previously reported. One or more palms were found to be in-

fectured with *Omphalia* in about three-quarters of the orchards where 10 or more samples were taken. Most of the root sampling was done by request, and it is not known whether the orchards examined constitute a fair cross section of the date orchards in the Coachella Valley.

Acknowledgment is made to the staff of the U. S. Date Garden for granting the survey temporary laboratory and greenhouse facilities; and to Dr. Donald E. Bliss, who did basic research on *Omphalia* root rot (2), for demonstration of his techniques and supplying valuable records.

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BUNCH PROTECTION OF THE KHADRAWY DATE IN RELATION TO SUNBURN AND FRUIT SHRIVEL

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From time to time in recent years there has been considerable sunburn of fruitstalks and strands of the Khadrawy date. The palm of this variety has a relatively open crown and rather short fruitstalks, which result in greater exposure than in Deglet Noor and some other varieties grown commercially. After the writer had investigated a number of cases in which pronounced sunburn of the Khadrawy was associated with the use of brown paper covers similar to those used on Deglet Noor, experiments were started at the U. S. Date Garden to study the relation of bunch protection to sunburn and fruit shrivel.

On July 27 and 28, 1943, on each of 30 Khadrawy palms, 8 years old, one bunch wrapped only with a good grade of cotton gauze was paired with a comparable bunch wrapped in the same way but covered with a brown paper tube, or bag, in addition. A similar experiment was conducted the following year, beginning on August 9 and 10, with 14 replications and with one additional treatment of white paper. An effort was made to secure a white paper comparable in every respect to the brown now in use except for color, but under war conditions the best that could be obtained was about half as heavy. Table 1 shows the sunburn that resulted from these treatments as indicated by brown discoloration of the strands. There was no apparent injury to the fruitstalks. More than three-fourths of the bunches covered with brown paper showed more or less sunburn and on more than half of the bunches it was classed as pronounced because as much as one-fourth of the total number of strands on a bunch were affected, with the discoloration entirely encircling some of the strands and extending for a length of more than two inches. The check bunches and those covered with white paper showed very little sunburn and on only one bunch in either of the two treatments was the discoloration of strands pronounced.

A number of temperature readings were obtained from mercury thermometers in different parts of the bunches. In one instance when the air temperature outside was 105° F., a temperature of 153° F. was recorded on the inside of, and

Table 1. Number of Bunches with Strands Showing Evidence of Sunburn As Indicated by Brown Discoloration.

Treatment	Date	Total	NUMBER OF BUNCHES			
			Slight to moderate sunburn	Percent	Severe sunburn	Percent
Check	9-1-43	30	2	7	1	3
Brown Paper	9-1-43	30	12	40	13	43
Check	9-11-44	14	6	43	1	7
Brown Paper	9-11-44	14	4	29	9	64
White Paper	9-11-44	14	4	29	1	7

touching, the exposed portion of a brown paper bag. Comparable readings from beneath white paper bags under similar conditions were about 15 to 35 degrees lower. Studies that have been reported with other plant tissues suggest that definite injury could be expected from a temperature as high as 150° F. However, only fruit or strands touching or very close to the exposed part of the bag would be likely to be affected as, at the same time that 153° F. was recorded as indicated, the center of the open space above the fruit under the bag was only 115° F. This explains the fact that discoloration from sunburn was observed mostly on the most exposed portions of the bunch under the brown bags. Except adjacent to the exposed portion, temperatures under the white bags were comparable to or only slightly lower than those under the brown bags. Temperatures under gauze covers were comparable to those under white paper. Temperatures in the center of the bunch in the fruit zone were 5 to 10 degrees lower than outside air temperature during the middle of the day.

The fruit grade records for these two experiments are shown in Table 2, each representing the average of two pickings. The differences between treatments with regard to sunburn were not followed by corresponding differences in grade, although in 1943 there was about twice as much fruit in the substandard grade from brown bags as from checks. Most of the fruit placed in that grade was shriveled enough to be lowered in dry weight but still

had enough flesh to be usable as food; in the strand counts it was classed as severe shrivel. Any shrivel more pronounced (fruit without substance) was graded as culls, but this classification also included fruit unusable because of rot or other reasons. Hence, as far as these records are concerned, the substandard grade affords the best index to shrivel. In 1944 there was little difference in shrivel between any of the treatments. The higher percentage of choice or better for the bunches enclosed in brown paper in 1944 appeared to be partly due to delayed ripening.

The difference between choice and standard (the latter including No. 1 dry) is primarily a matter of appearance and moisture content or consistency of flesh. Both of these factors are affected by the drying incident to delayed picking. Some light on the differences which obtained between treatments in this respect is brought out by data from strand counts prior to the first picking shown in Table 3.

Ripening was delayed by bagging. The differences were slight but consistent, and may possibly be due to differences in exposure to the drying effects of air movement. Since all the ripe fruit was picked at the same time, the earlier ripening fruit in the checks was subjected to longer drying than that in the treatments under paper. Drying beyond a certain point renders the fruit less attractive by increasing wrinkling and blistering (separation of skin and flesh) and decreasing size.

It will be noted that in 1943, in

Table 2. Fruit Grade Record from Experiments Shown in Table 1. (Percent).

	Choice	Standard	Subst.	Culls
1943				
Check	18.7	73.3	7.7	0.3
Brown Paper	20.2	62.5	14.1	3.2
1944—				
Check	39.3	55.4	4.3	1.0
Brown Paper	57.0	36.9	5.9	5.9
White Paper	52.1	39.5	2.7	5.7

spite of the increase in the percentage of fruit graded as substandard when the bunches were covered with brown paper, the strand counts prior to picking showed no difference in the percentage of severely shriveled fruit which made up most of the substandard grade. This is explained by the fact that no strands that showed severe injury from sunburn were selected for the count, although they were otherwise chosen at random, 2 from the center, 2 from the outside and 2 from portions of the bunch in between. This was done because there was an obvious relation between severe shrivel and extreme injury to the strand, which it was desired to eliminate in the strand counts in order to determine if there were other factors involved in the treatment that might contribute to severe shrivel, as well as to slight shrivel and maturity.

Fruit was classed as slightly shriveled if it showed slight wrinkling of the skin while still retaining the khalal color. From daily observations on a large number of marked specimens it was determined that slightly shriveled fruit finally reached a normal maturity and was then comparable to fruit that first lost khalal color and became translucent before wrinkling in the final shrinkage of ripening. Dry weight samples gave evidence that this slight khalal shrivel was associated with advanced maturity. In a series of 8 paired samples, each from the same bunch, slightly shriveled dates had an average dry weight per fruit of $6.21 \pm 0.25^*$ gms. while plump khalal dates of the same apparent size and color averaged only $5.09 \pm 0.26^*$ gms. per fruit. At the same time, in another series of 10 paired samples, normal ripe dates were found to average $7.01 \pm 0.15^*$ gms. and severely shriveled ripe dates (mostly from sunburned strands because they very seldom occurred on others) only $4.85 \pm 0.15^*$ gms. In both comparisons the differences are highly significant statistically. From these data and observation it would appear that severe shrivel results from some interference in the normal growth processes beginning prior to the full khalal stage.

There was a definite tendency for more slight shrivel to occur on the

check bunches than on those under bags. Although the difference was slight in 1943, it was evident in 1944 and more pronounced in the 1945 experiments described later. The check bunches were, of course, more exposed to the drying effects of air currents.

Evidence was also obtained that low soil moisture increased the percentage of slightly shriveled fruit. The palms used in these experiments were about evenly divided between the wet and dry plots of an irrigation experiment. In the dry plots water was withheld in late summer. While the data have been here presented as a unit for each bunch treatment, when broken down according to irrigation treatments there appeared a clear-cut relation to slight shrivel. For example, the 1944 data given in Table 4 show a consistent increase in percentage of

Table 4. Percentage of Slightly Shriveled Fruit In Wet and Dry Plots — 1944.

	Wet	Dry
Check	13.0	18.2
Brown Paper	5.6	16.8
White Paper	4.6	13.0

slight shrivel in the dry plots regardless of bunch treatment.

In view of the fact that injury from brown paper covers in 1943 was primarily to the strands with very slight effect on the fruitstalk, another experiment was conducted with Khadrawy palms in 1944 to study the effects of definite injury to the fruitstalk. On July 6 and 7 on each of 13 palms six different treatments were given to the fruitstalks as indicated in Table 5. By the end of July some brownish discoloration was beginning to show under the black cloth and the black paint. The fruitstalks listed as severely injured, had, prior to the first picking, dark brown discolored areas entirely across the upper surface and for 6 inches or more of length, with some of the central portions of the discolored areas beginning to dry and crack. There was no well-defined discoloration of fruitstalks except under the black cloth and black paint. This injury was very definitely associated with a large percentage of severely shriveled fruit; in fact most of the fruit on the severely injured fruitstalks was of that type, and this accounts for the high percentage of sub-

standard and cull fruit in the grade records. Strand counts showed a high percentage of severely shriveled dates on bunches whose fruitstalks were covered with black cloth and black paint, but a negligible percentage for the other treatments. There was only a slight increase of slightly shriveled fruit associated with the injured fruitstalk.

Because of the rather poor showing in fruit grade from bunches whose fruitstalks were painted with white cold-water paint, the treatment was repeated in 1945 with a much larger number of replications so as to eliminate the possibility that chance variations in exposure or other factors were responsible for the results in 1944. Untreated fruitstalks were compared with those covered with white cold-water paint in 50 pairs of bunches on Khadrawy palms. On 14 additional bunches white paper covers were tried again. Under war conditions it was not possible to obtain more of the white paper covers. The results are shown in Table 6.

White cold-water paint on the fruitstalks did not make much difference in the grade of fruit. The check bunches had about twice as much substandard fruit. In analyzing the data this increase in substandard fruit appeared to be due primarily to 6 bunches which had from 24 to 98 percent of the fruit in that grade, whereas the 50 bunches with fruitstalk covered with white paint had none with more than 20 percent. On these 6 check bunches the substandard fruit was due to severe shrivel and appeared to be correlated with sunburn of the fruitstalks. Unfortunately, detailed notes on sunburn were not attempted until October 4 and this was too late to check differences, as by that time there was too much dying back of strands and fruitstalks due to all the fruit being full ripe.

In 1945 the outstanding result was the heavy loss from fruit rot for the paper-covered bunches as compared with a very slight loss for bunches with cloth alone. Only one picking (September 20) was made, but about 90% of the total crop was harvested at that time. Losses from rot were estimated at about 70% for fruit under the bags as compared with about 15% for fruit not bagged. The grade records in Table 6 represent random samples taken after fruit obviously affected from rot was supposedly removed by pickers in the field, yet there were 4 to 5 times as many culls (all rot in this case) from the bunches covered with paper as from either of the other two treatments.

The development of fruit rot in the centers of bunches under bags

Table 3. Condition of Fruit Prior to First Picking. (Percent).

	Ripe	Slightly Shriveled	Severely Shriveled
1943, Aug. 30			
Check	31.2	9.2	1.7
Brown Paper	23.0	8.0	1.6
1944, Sept. 12			
Check	24.2	15.2	1.4
Brown Paper	13.6	10.4	1.6
White Paper	12.9	8.2	0.9

* Standard error.

Table 5. Effect of Different Fruitstalk Treatments on Sunburn and Fruit Grade — 1944.

TREATMENT	Number of fruitstalks sunburned out of total of 13 in each treatment		GRADE RECORD (percent)				STRAND COUNTS (percent)		
	Slight to moderate	Severe	Choice	Standard	Subst.	Culls	Slight Shrivel	Severe Shrivel	Fruit Ripe
Fruitstalk covered with:									
Check—no covering	0	0	55.2	41.5	2.5	0.8	9.0	0.2	19.1
Insulation of asbestos	0	0	51.3	44.0	4.4	0.3	11.6	1.5	23.9
Black cloth	5	7	18.9	47.4	26.3	7.4	18.1	37.4	26.4
White cloth	0	0	43.8	51.5	4.4	0.3	12.8	0.2	20.6
Black cold-water paint	4	7	27.8	46.4	20.6	5.2	17.1	16.7	28.8
White cold-water paint	0	0	38.5	51.2	8.3	2.0	12.4	0.4	20.1

was observed from time to time prior to harvest. During the latter part of August a few determinations of humidity in the centers of bunches were made from wet and dry bulb readings with an aspirator type psychrometer. On clear but rather humid days the relative humidity in the center of bunches under paper covers was 10 to 15 percent higher than in bunches covered only with gauze, and in the latter it was 10 to 15 percent higher than the air outside. Several different times when examined during the forenoon, dates in the center of a bunch under paper were found to be covered with moisture. This was not observed in bunches covered only with light cloth. The use of bags in 1945 was distinctly detrimental

because of the increase in fruit rot even though there was no injury from sunburn.

Summary

Sunburn on the Khadrawy variety was increased by the use of brown paper covers of the kind now used on Deglet Noor; but sunburn as indicated by brownish discoloration did not seriously lower the grade of fruit except where there was very pronounced injury to strands or fruitstalks. The absence of any marked tendency to sunburn under white paper or on fruitstalks covered with white cold-water paint suggests the possibility of using these methods in some cases with varieties whose bunches are much exposed. Sometimes there are high-

er temperatures in late summer in Coachella Valley than occurred during the period of these experiments. Results in 1945 indicate that in humid weather the use of paper covers of the present commercial type, regardless of color, greatly increases the incidence of fruit rot. On the basis of these experiments paper bags of the type used on Deglet Noor could not be recommended for the Khadrawy variety.

From these studies it appears that there are two types of shrivel in the Khadrawy date. Shrivel severe enough to cause a large reduction in dry weight and to throw the fruit into substandard or cull grades seems to result primarily from an interruption in the movement of dry matter to the fruit and was associated in these experiments with pronounced injury to strands or fruitstalks from sunburn. Slight shrivel, which may be observed in the khalal stage, seems to result from any condition that promotes drying of the fruit and was associated in these experiments with exposure of the bunch and with a deficiency of soil moisture in late summer. Slight shrivel does not necessarily affect quality but may increase the percentage of fruit in the drier grades.

Table 6. Effect of Fruitstalk and Bunch Treatments on Khadrawy Fruit — 1945.

TREATMENT	Check	White cold-water paint on fruitstalk	White paper cover on bunch
(Grade record Sept. 20, average percentage)			
Choice	5.9	5.4	6.9
Standard	74.7	81.1	50.7
Substandard	10.3	5.9	5.4
Culls	9.1	7.6	37.0
(Strand counts Sept. 6, average percentage)			
Fruit ripe	30.9	32.1	19.1
Fruit slightly shriveled	33.6	30.4	15.7
Fruit severely shriveled	2.9	2.4	1.7

THE USE OF FUNGICIDES AGAINST SPOILAGE IN DATES*

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The fungicidal treatment of dates to control fruit rots was first employed experimentally in Arizona by Brown and Gibson (4). Although some control was obtained by direct application of fungicides to the fruit surfaces, Brown (3) reported abandonment of this method of treatment because of difficulty in removing the spray residue without ruining the fruit for market. He also attempted to control fungus spoilage by spraying the leaves, spathes, and trunks of date palms in April before the spathes opened; but this treatment, which was intended to reduce the amount of fungus inoculum, gave somewhat variable results, and fruit rot was not prevented.

In California partial control of spoilage was achieved by means of paper fruit protectors, or bags, used to protect the fruit from rain, and by means of wire rings so placed as to increase aeration at the center of fruit bunches (1, 2). The disastrous loss of dates in 1939, however, gave decisive evidence that new and more positive control measures were needed.

In 1940 I began to search for an effective fungicide that could be easily removed from ripened date fruits, and that would be nontoxic to man when consumed in small quantities. Many fungicides were considered, but most promise was found in certain newly developed organic chemicals that could be applied in dust form. Talc was used at first as a diluent for the experimental dust fungicides, but sulfur dust was later substituted for talc because

it was already being applied directly to immature dates for the control of the date mite, sometimes called the "red spider," *Paratetranychus simplex* (Banks) [*P. heteronychus* Ewing] (7). The desirability of the sulfur treatment, both from the standpoint of effective mite control and from the standpoint of the apparent tolerance of the date palm to sulfur, prompted its use as a diluent or carrier. The possibility of controlling the development of both the mites and the fruit-spoilage fungi with the same treatment seemed worthy of investigation. Field experiments were begun in 1940 and continued each year except in 1942. The first experiments were of little or no value, but in 1944, and especially in 1945, results were obtained which indicated that considerable benefit might result from fungicidal treatments.

Materials and Methods

Eleven fungicides were applied, singly or in combination, to date fruit on 251 fruit bunches, in experiments conducted in the Coachella Valley of California, as follows: in 1940, B. S. Boyer orchard, Indio; in 1941 and 1943, Mecca Plot, Mecca; and in 1943-1945, U. S. Date Garden, Indio. Fruit of the Deglet Noor variety was included in all experiments, but fruit of Khadrawy, Hayany, Tazizoot, and Iteema varieties was also included in some.

The experimental fungicidal treatments were regularly made in August (one application per year), during the khalal stage of fruit maturity. Two applications were made in 1945, however; the first on July 5, as a protectant against fungus infection and mite injury; and the second on August 28, principally against fungus infection. Liquid fungicides were applied with a knapsack sprayer; dusts were applied with hand dusters, care being taken to obtain a thorough coverage of all fruit surfaces.

The palms selected for experimental purposes were mostly of such height that the fruit could be treated and picked from the ground or from a short ladder. In late August, at time of "bagging," wire baskets were suspended under the experimental bunches of Deglet Noor fruit to catch all dates that dropped dur-

ing the ripening season. The dates were picked at 10-day intervals as they ripened, and were taken to the laboratory, where they were weighed, rated for quality, and examined individually for evidence of fungus spoilage. Most of the fruit was dry-cleaned in cloth toweling after fungus-infected and other cull dates had been removed, but the fruit with the residue of bordeaux mixture was washed with N/10 hydrochloric acid for 15 seconds, rinsed in tap water, and dried quickly in air from an electric fan. All fruit was distributed for domestic use. This procedure was intended to simulate, so far as possible, that employed for other dates in commercial channels. In recording the results of these experiments, special attention was given to fungus spoilage, fruit quality, the removal of fungicidal residues, and the edibility of the processed fruit.

The Effect of Weather on Fruit Spoilage

Of various atmospheric conditions affecting the development of fruit spoilage by fungi, temperature and moisture are of particular importance. The temperatures that occur during the critical khalal and rutab stages of fruit maturity are usually favorable to fruit spoilage, but moisture is usually lacking during this period. Lack of moisture, therefore, becomes the limiting factor in disease development. The wind-borne spores of certain soil fungi are deposited on all fruit surfaces and require only the presence of dew or rain for their germination. The infection stage of fruit spoilage by fungi begins only a few hours after spore germination, and the disease process is then no longer dependent on atmospheric moisture for further development.

In the years 1942-1945, inclusive, the atmosphere at the U. S. Date Garden was relatively dry during the month of June but tended to become increasingly moist during the remainder of the year. Days of high relative humidity occurred much more frequently during the months of July and August, 1945, than during similar periods in the two preceding years (table 1). There were also frequent traces of rain during the summer of 1945, in addition to a heavy rainstorm on August 19 and a lighter one on Sep-

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Table 1. Number of days having a relative humidity of 60 per cent or more at 7:00 A.M., U. S. Date Garden, Indio, California, June to December, inclusive, 1942-1945.*

Month	1942	1943	1944	1945
June	1	0	0	0
July	9	0	0	9
August	10	10	4	16
September	1	9	9	11
October	9	17	13	7
November	15	6	25	3
December	19	24	19	20

* Climatological Data, California Section, U. S. Weather Bur., vols. 46-49, 1942-1945.

tember 9 (table 2). Although the total precipitation in 1945 was not unusually great, the distribution of moist weather was admirably suited to the development of water injury and fungus fruit spoilage during the most critical stages of fruit maturity. Notable periods of moist weather had also occurred in 1940, 1941, 1943, and 1944, but these came after October 10, when most of the dates had passed the critical stage (8). 1945 stands out, therefore, as the only year during the period of these experiments, in which the weather was conducive to

fruit spoilage of serious proportions.

Results

Fungicidal treatments in the experiments of 1940 and 1941 produced no significant differences in fruit spoilage by fungi. Less than 2 per cent fungus spoilage occurred. In 1942 fungus spoilage was again almost nil, and no field experiments were conducted.

The fungicidal treatments in 1943 included liquid bordeaux mixture, and sulfur dust used alone and in combination with Spergon and Fer-

mate, and with manganese dimethyl dithiocarbamate in talc. Injury from mites was observed at the Mecca Plot on fruit bunches that had not been treated with sulfur dust used alone or in combination with other chemicals.

The treatments at the U. S. Date Garden in 1943 gave the first indication of success in controlling fungus fruit spoilage (table 3). Although untreated Deglet Noor dates showed only 3.11 per cent spoilage, those dusted with sulfur showed only 0.58 per cent spoilage, a value significant at the 5 per cent level, as shown by the "t" test (6).

Cleaning with a dry cloth removed the residues of sulfur and of the Fermate-sulfur mixture more effectively than it did those of the Spergon-sulfur mixture and of the mixture of manganese dimethyl dithiocarbamate, talc, and sulfur. Dry cleaning was ineffective against the residue of bordeaux mixture, which was removed with dilute hydrochloric acid. Dry dates withstood this washing very well and may possibly have been improved by it, but some of the moist ones were injured by skin-tearing.

In the 1944 experiment, attention was focused on treatments with bordeaux mixture, sulfur, and Fermate, the Fermate being applied both in a liquid spray and in a dust containing sulfur. The year was remarkable for the slowness of fruit-ripening and the high quality of dates produced. The early ripening season was dry, but the cool, moist weather throughout November further retarded ripening and increased fungus spoilage in the later fruit bunches. Almost no shriveling or blacknose was found in the experimental fruit, and checking was either very slight or entirely absent. Most trouble resulted from shattering of khalal-stage fruits during the early pickings, and the formation of small cracks or tears at the calyx end of immature dates during the November rains. These tears exposed the underlying flesh to infection by various molds.

In 1944, the liquid fungicidal treatments with bordeaux mixture and with Fermate proved to be of little or no value. The dust treatments, however, with sulfur alone and with Fermate-sulfur mixture, were followed by a significant reduction in fungus spoilage and by an increased fruit-quality rating (table 3). Small amounts of dust remained in the wrinkles of the dates after they were dry-cleaned, but these slight residues did not seem objectionable from the standpoint of appearance or taste. Because of its dark-gray color, the residue of the Fermate-sulfur dust

Table 2. Rainfall recorded at the U. S. Date Garden, Indio, California, June to December, inclusive, 1940-1945.*

MONTH	Day	1940		1941		1942		1943		1944		1945	
		Rainfall in inches	Day	Rainfall in inches	Day	Rainfall in inches	Day	Rainfall in inches	Day	Rainfall in inches	Day	Rainfall in inches	Day
June	.....	.....	.....	.....	.....	.....	.....	19	trace	.....	.....	22	trace
July	14	0.02	.....	.....	.....	.....	.....	7	trace	.....	.....	8	trace
	.....	.....	.....	.....	.....	.....	.....	28	trace	.....	.....	9	trace
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	18	trace
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19	trace
Aug.	.....	.....	10	0.82	.....	.....	.....	2	0.61	10	trace	3	0.04
	.....	.....	11	0.64	.....	.....	.....	15	trace	.....	.....	12	trace
	.....	.....	15	trace	.....	.....	.....	.....	.....	.....	.....	18	0.14
	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	19	2.20
Sept.	2	trace	12	0.01	.....	.....	.....	25	0.26	16	0.02	9	0.52
	11	0.03	28	trace	.....	.....	.....	26	0.06	.....	.....	.....	.....
	12	trace	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	17	0.03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oct.	26	0.03	12	0.05	13	trace	10	0.14	23	0.04	5	0.21	.....
	.....	.....	13	trace	29	0.03	18	trace	24	trace	7	trace	.....
	.....	.....	22	0.06	.....	.....	.....	.....	25	trace	8	trace	.....
	.....	.....	23	0.11	.....	.....	.....	.....	.....	.....	.....	.....	.....
	.....	.....	24	0.68	.....	.....	.....	.....	.....	.....	.....	.....	.....
Nov.	16	trace	12	1.03	.....	.....	.....	.....	5	0.28	.....	.....	.....
	17	trace	13	0.46	.....	.....	.....	.....	6	0.32	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	.....	12	0.35	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	.....	14	0.15	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	.....	15	0.08	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	.....	16	trace	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	.....	17	trace	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	.....	23	trace	.....	.....	.....
	.....	.....	.....	.....	.....	.....	.....	.....	24	trace	.....	.....	.....
Dec.	9	trace	10	0.07	18	trace	6	0.07	3	trace	11	trace	.....
	13	trace	12	0.20	25	0.14	7	0.12	25	trace	22	0.36	.....
	16	0.47	24	0.01	.....	.....	8	trace	26	0.12	23	0.85	.....
	23	0.02	26	0.05	.....	.....	10	1.50	28	0.03	24	0.02	.....
	24	2.36	29	0.31	.....	.....	11	1.30	29	trace	.....	.....	.....
	29	0.08	.....	.....	.....	.....	12	0.15	.....	.....	.....	.....	.....
	30	0.01	.....	.....	.....	.....	18	0.03	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....	19	0.10	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....	20	trace	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....	21	0.05	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....	.....	31	0.10	.....	.....	.....	.....	.....

* Information supplied through the courtesy of the Staff of the U. S. Date Garden, Indio, California.

Table 3. Effect of fungicidal treatments on fungus spoilage and rating of Deglet Noor Dates, U. S. Date Garden, Indio, California, 1943-1945, inclusive.

TREATMENT*	Number of Fruit Bunches	Total Fruit, kg.	Fungus Spoilage, per cent	Fruit-Quality Rating (10=perfect)
1943				
None (control)	5	54.7	3.11	6.9
Bardeaux mixture (liquid)	5	51.2	2.21	6.7
Sulfur (dust)	5	55.1	0.58**	6.7
Spergon and sulfur (dust)	5	47.8	0.63	6.7
Fermate and sulfur (dust)	5	58.6	0.92	6.9
Manganese dimethyl dithiocarbamate (in talc) and sulfur (dust).....	5	55.8	0.73	6.8
1944				
Nane (control)	6	55.8	3.70	7.2
Bordeaux mixture (liquid)	6	57.6	3.21	7.0
Fermate (liquid)	6	56.0	4.17	6.8
Sulfur (dust)	6	58.5	0.66**	7.4
Fermate and sulfur (dust)	6	63.5	0.64**	7.6
1945				
Nane (control)	5	42.6	53.18	3.5
Sulfur (dust)	5	41.2	46.30	4.0
Fermate and sulfur (dust)	5	46.1	11.11***	5.7
Dithane (liquid)	5	40.8	37.90	4.1
Yellow Cuprocid and sulfur (dust).....	5	50.9	8.50***	5.2
Phygon (liquid)	6	55.9	38.22	3.7

* Fungicidal treatments applied August 2, 1943; August 7, 1944; July 5 and August 28, 1945.

** Values significant at the 5 per cent level, as shown by the "t" test (6).

*** Values significant at the 1 per cent level.

mixture was less noticeable than that of sulfur dust.

In 1945, there was an unusual amount of fungus fruit spoilage in the Coachella Valley. The experimental treatments included sulfur and Fermate-sulfur dusts, a mixture of Yellow Cuprocid and sulfur dust, Dithane spray, and Phygon spray. These fungicides, first applied on July 5, when the dates were green and half grown (kimri stage), were mostly removed by a heavy rainstorm on August 19. They were applied again on August 28, when the dates were red and full grown (khalal stage). The installation of paper fruit protectors, or bags, at that time afforded rain protection and maintained adequate fungicidal coverage on the dates throughout the harvest season.

The fruit bunches used in the 1945 experiment had been pollinated during the period March 13 to April 24, inclusive. On September 13, I noticed that the relatively mature, early-pollinated bunches had more fungus spoilage than the immature, late-pollinated bunches. Calyx-end rot, caused mostly by *Aspergillus niger* V. Tiegh, was at that time the principal type of fungus spoilage. Types of nonpathogenic spoilage were also evident. Some tearing had occurred, but the

injury from severe chocking and blacknose was much more important. There was also considerable fruit-shriveling, which could be partially attributed to vascular injuries from mechanical breakage or from sunburning. By September 29, when the first-ripened fruits were picked, the early-pollinated bunches contained so many rotting dates that a veritable shower of them would fall when the fruitstrands were disturbed. Both the calyx-end rots and the side spots caused by *Alternaria citri* Ellis and Pierce em. Bliss and Fawcett, and by *Pleospora herbarum* (Pers. ex Fr.) Rabenh., and others, were common; but as the season progressed, the side spots predominated as the principal type of fungus injury. Whereas side spots were found on 46 to 82 per cent of the fungus-infected dates in the second fruit picking (October 11), there were side spots on 67 to 100 per cent of the infected dates in the fifth picking (November 30). Green molds (*Citromyces ramosus* Banier and Sartory, and *Penicillium* spp.) commonly produced their spores inside the dates; and various yeasts (*Candida* spp. and others) were associated with fermentation and souring. The adults and larvae of certain beetles (*Carpophilus* spp.) were also found in great

abundance, especially in and about sour or decaying fruits. By the end of the harvest season, there had been about as much fungus injury in the late-pollinated bunches as in the early ones. About 75 per cent of the Deglet Noor dates in the experimental orchard had been lost from all types of fruit spoilage, and two thirds of this loss could be attributed to fungus spoilage.

It was evident from the time of the first fruit picking that certain experimental treatments had reduced fungus spoilage. The treatments with Fermate-sulfur mixture and with Yellow Cuprocid-sulfur mixture were outstanding in this regard. Whereas during the entire season, 53.18 per cent of the untreated (control) dates were affected with fungus spoilage, only 11.11 per cent of the dates treated with Fermate-sulfur mixture were affected, and only 8.5 per cent of those treated with Yellow Cuprocid-sulfur mixture (table 3). These values were found to be highly significant. Some reduction in fungus spoilage was also obtained from treatments with Dithane, Phygon, and with sulfur, but those values were not significant, either at the 5 per cent or at the 1 per cent level.

The quality rating of fruit samples also reflected important differences between the various treatments (table 3). Fruits treated with the Fermate-sulfur mixture were considered equal or superior to fruits of the controls and of all other treatments in three years' experiments. This superiority was based on the relative occurrence of fungus fruit spoilage, on freedom from chemical injury, and on the control of mites. In 1945 the fruit treated with Yellow Cuprocid-sulfur mixture had slightly less fungus spoilage than that treated with Fermate-sulfur, but part of it had shriveled. Relatively few beetles (*Carpophilus* spp.) were found in date bunches where fungus spoilage had been nearly eliminated. Dithane and Phygon sprays were objectionable because small oval scars remained on the underside of dates where drops of spray mixture had collected. These scars were marked by numerous checks radiating from the center.

The removal of fungicidal residues was generally satisfactory in 1945. The liquid spray treatments with Dithane and Phygon had left no visible residues. The residues from the dust treatments with sulfur, Fermate-sulfur, and with Yellow Cuprocid-sulfur, were effectively removed by rubbing with a dry cloth, except in the wrinkles of the fruit, where the cloth did not touch, and in occasional patches where the surface had become

sticky. Sulfur was more conspicuous on the fruit than the other two dusts because of its lighter, yellow color.

Samples of treated dates were taken to the packing house of the California Date Growers Association at Indio, where, through the courtesy of Mr. Yowell, the superintendent, two types of cleaning were employed, special attention being given the fruit treated with Fermate-sulfur mixture. The first method of cleaning, on a shaker table lined with turkish toweling, was thought to be about equal to the method used in the laboratory. The second method of cleaning, by means of dry, rotating brushes, proved to be superior to the first, however, the dates being well polished and very attractive in appearance. Mr. Yowell concluded that the removal of the residue of Fermate-sulfur mixture would present no important difficulties in the packing house.

Other samples of treated dates from the 1945 experiment were submitted to the Bureau of Chemistry of the California State Department of Agriculture, for inspection and chemical analysis. These dates had been rubbed with a dry cloth in the laboratory. In a letter to the writer under date of January 15, 1946, Mr. Allen B. Lemmon, Chief of the Bureau, reported his findings as follows:

Sample	Fungicidal Residue	Parts per Million Found
A	Control	— —
B	Sulphur (as elemental).....	20.14
C	Fermate (ferric dimethyldithiocarbamate)	10.40
	Sulphur (as elemental)	20.25
D	Zinc (as metallic)	5.80
	Dithone (disodium ethylene bisdithiocarbamate)	1.68
E	Copper (as metallic)	7.27
	Sulphur (as elemental)	11.42
F	U. S. Rubber Co. "604" (Phygan) (2,3-dichloro-1,4-naphthoquinone)	1.59

Mr. Lemmon commented: "The preliminary data with regard to toxicity of various compounds available in our files indicate that the amounts of sulphur, zinc, and copper found in these analyses would not present any significant hazard to human health. However, it is possible that these amounts may have some detrimental effect on palatability. We have no information with regard to the health hazard involved in the residues of ferric dimethyldithiocarbamate, disodium ethylene bisdithiocarbamate, or 2,3-dichloro-1,4-naphthoquinone, but the amounts found seem not excessive."

In a previous letter (under date of December 18, 1945), Mr. Lemmon had stated: "So far as we know, there has been no investigation of the health hazard involved

in residues of elemental sulphur on fruits, but such residues are generally believed to be relatively innocuous to human beings. Although no official tolerance for copper residues has been promulgated by federal or state authorities, we understand that some offices have a working tolerance for copper expressed as metallic of approximately 30 mg. per kg. We know of no tolerance for zinc compounds on foodstuffs, but have generally regarded them in the same class as copper compounds. We have no information with regard to any health hazard involved in residues of ferric dimethyldithiocarbamate, disodium ethylene bisdithiocarbamate, or 2,3-dichloro-1,4-naphthoquinone, but it is possible that any potential hazards may have been investigated by the manufacturers of these chemicals, and you may be able to obtain some information from them."

Dr. Harry F. Dietz, of the Pest Control Research Section, Grasselli Chemicals Department, E. I. du Pont de Nemours and Co. (Inc.), in a letter dated December 19, 1945, to the writer, stated: "The relative toxicity of Fermate to warm-blooded animals is of a very low order. In the quantity that you are contemplating using it, namely, at 5% in a sulfur dust, it should not be harmful, even if applied within a relatively short time before the dates are harvested. It is currently being used on dark colored sweet cherries, particularly for brown rot control, applied within a week or ten days prior to the picking of the fruit."

Mr. John L. Harvey, Chief, Western District, Federal Security Agency Food and Drug Administration, in a letter dated January 17, 1946, to the writer, stated: "No tolerance has been established for either sulfur or ferric dimethyl dithiocarbamate as a residue in foods. Tolerances are established under authority of the Food, Drug, and Cosmetic Act, for poisonous ingredients in foods only where such added substances are required in the production of the food or cannot be avoided by good manufacturing practice. A food is adulterated if it bears or contains any poisonous or deleterious substance which may render it injurious to health. We are unable to express an opinion as to the toxicity of 'Fermate'. In addition to consideration of the Sulfur-Fermate dust as a spray residue the question also arises as to whether the residue remaining on the harvested fruit serves the purpose to any extent of a fungicide to preserve the fruit. If so, the substance is an added chemical preservative and the labeling for the food must bear the name of such preservative and a statement of the

fact that it is a preservative. It is the obligation of producers and shippers who employ a spray material or a preservative to determine comprehensively that the added substance constitutes no hazard to the health of consumers."

After the dates of all the fungicidal treatments mentioned in these experiments had been cleaned in the laboratory, they were distributed for domestic use. No complaints of nonedibility were received, and, so far as is known, the palatability of the fruit was not greatly altered. The fruits treated with Fermate-sulfur mixture and cleaned were thought to be essentially as attractive, as palatable, and as free from poisonous effects as the nontreated fruits.

Discussion

Growers who have experienced disastrous crop losses in years such as 1939 and 1945 will agree that up to the present time fruit spoilage has been the most serious hazard in date production. Date-fruit spoilage can probably never be entirely prevented, but there are now some indications that crop losses can be reduced to such a low level that production will be generally stabilized.

Of the various means of reducing date-fruit spoilage, the fruit protector (bag) has probably been of greatest value. The paper tube, gathered at the top and tied about the fruitstalk, protects the dates from rain, but it also retains the moisture of transpiration within the fruit cluster. The removal of the center fruitstrands, and the insertion of a wire ring, have been suggested to reduce relative humidity within the fruit bunch by increasing aeration. Unfortunately, the date rings have not been generally adopted, and thinning of center fruit is not very effective in aerating the bunch after the dates are full grown.

The principle of aerating dates during periods of moist weather is fundamentally sound as far as it goes. Aeration appears to have greater effect in reducing water injury than in reducing fungus rot, but both types of spoilage are reduced to a limited extent. Free moisture is apt to condense on fruit surfaces during periods of high relative humidity despite all efforts to the contrary. Fungicidal protection is especially needed under these conditions. Hundreds of fungus spores, already deposited on the surface of every date fruit, are ready to germinate and invade the tissues if free moisture is supplied only for a few hours. An effective fungicide prevents infection either by killing the spore or by inhibit-

ing its germination. If the fungicide is not applied to the date until after the beginning of the infection stage (after the fungus mycelium has entered the tissues underlying the epidermis either by direct penetration of the cuticle and epidermis or by entry through a wound), it will have little or no effect on the development of fungus spoilage. The fungicide should therefore be considered as a protectant and not as a curative agent.

The search for an effective fungicide that is easily removed from the ripened dates and is nontoxic to man, has been carried through the preliminary steps. One fungicide consisting of 5 per cent Fermate in sulfur has been found to fulfill these requirements fairly well. We should not assume, however, that this particular mixture is necessarily the final solution to the problem. Before it is definitely recommended, it should be used extensively on an experimental basis, and should be tested further under the most rigorous conditions. The date grower should know that Fermate-sulfur mixture is not good to breathe, that it is apt to irritate his eyes, and that there is a possible danger of chemical injury (burning) to fruit that has maximum exposure to the sun.

As to the possible health hazard involved in the residues of the Fermate-sulfur mixture, no direct toxicological evidence is available. There is considerable indirect evidence that it is essentially nonpoisonous, but since the federal and state authorities have promulgated no tolerance for it (that is, no residue of this type is allowed), it behooves the date packers to clean the treated dates as well as possible. No preservative action on the packed fruit is intended. Dusted dates may be exposed to fungus infection after being washed by the rain, or they may be exposed as a result of their natural basipetal type of growth (5), for a date that is thoroughly covered with dust when half grown will later expose a broad band of untreated surface about the calyx end. Such exposure should be remedied by another application of dust.

To those wishing to test the Fermate-sulfur mixture on dates in their own orchards, the following tentative suggestions are made. Apply as a dust, using a good hand duster or other mechanical applicator capable of delivering forcefully a blast of dust that will cover all fruit surfaces. A thorough coverage of all dates is necessary during the period from midsummer, when the fruits are three-fourths grown, until they are mature. Two

applications will usually suffice: the first between July 1 and 15 (used principally against the mite), and the second between August 15 and September 15, following the installation of fruit protectors (bags).

In the Coachella Valley severe losses from fungus spoilage occur, on the average, about one year in five. Fungicidal application will be necessary every year, however, since the Fermate-sulfur mixture is only a fruit protectant, and no reliable methods are known for long-range weather prediction. The adoption by the industry of a fungicidal treatment for dates will eventually depend on whether the benefits derived from the treatment in moist years will justify the application of the fungicide every year as a standard horticultural practice.

Summary

In order to find an effective, nontoxic, and easily removable fungicide to be used against fungus fruit spoilage of dates, eleven fungicides were applied, singly or in combination, to date fruits in field experiments from 1940 to 1945, inclusive. During this period, 1945 was the only year in which the weather was conducive to fruit spoilage of serious proportions.

Significant values in the reduction of fungus spoilage were obtained with Deglet Noor dates after the following fungicidal treatments: sulfur dust (in 1943); sulfur dust, and a dust containing 5 per cent Fermate in sulfur (in 1944); and Fermate-sulfur mixture, and a dust containing 10 per cent Yellow Cuprocidate in sulfur (in 1945). Whereas in 1945, 53.18 per cent of the untreated dates were affected with fungus fruit spoilage, only 11.11 per cent of the dates treated with Fermate-sulfur mixture were affected. Fruits treated with Fermate-sulfur mixture were considered equal or superior in quality to fruits of the controls and of all other treatments in three years' experiments. Relatively few beetles (*Carpophilus* spp.) were found in date bunches where fungus spoilage had been nearly eliminated, and mites were controlled by dust fungicides containing sulfur.

In the laboratory, satisfactory removal of these most promising dust fungicides was obtained by rubbing the treated dates back and forth in a dry cloth. The only visible residue remaining was that between wrinkles in the skin, which the cloth failed to touch. In the packing house, about equally satisfactory cleaning of dates was obtained on a shaker table lined with turkish toweling; more effective cleaning was obtained with dry, rotating

brushes. The residue of the Fermate-sulfur mixture was less noticeable than that of sulfur dust because of its darker color.

Chemical analysis of treated Deglet Noor dates after they had been cleaned in the laboratory showed fungicidal residues, in parts per million, as follows: with sulfur dust alone: sulfur, 20.14; with Fermate-sulfur mixture: ferric dimethyl dithiocarbamate, 10.40, and sulfur, 20.25; and with Yellow Cuprocidate-sulfur mixture: copper, 7.27, and sulfur, 11.42. The various fungicidal treatments did not greatly alter the palatability of the dates cleaned in the laboratory. The dates treated with Fermate-sulfur mixture were thought to be essentially as attractive, as palatable, and as free from poisonous effects as the non-treated fruits.

Tentative suggestions are made to growers who wish to test the dust containing 5 per cent Fermate in sulfur. Since this dust is a fruit protectant having acaricidal properties against the mite, as well as fungicidal properties against the numerous fruit-spoilage fungi, it is desirable to maintain a thorough coverage of all fruit surfaces from mid-summer until fruit maturity.

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HERBERT JOHN WEBBER

1865 — 1946

Herbert John Webber, Professor Emeritus of Subtropical Horticulture of the University of California, died at Riverside, California, January 18, 1946. In his passing, horticultural science lost one of her great leaders. For his vision, energy, enthusiasm, intelligence, and generous spirit, we shall always be indebted to this great and genial man. He was the first Director of the University of California Citrus Experiment Station, and one of the founders of the Date Growers' Institute.

Dr. Webber was born near Lawton, Michigan, December 27, 1865, but he spent most of his boyhood on a farm in central Iowa. In 1883 the Webber family moved again to Lincoln, Nebraska, where Herbert attended the University of Nebraska, receiving the Bachelor of Science degree in 1889, and the Master of Arts degree the following year. On September 8, 1890, he married Miss Lucene Anna Hardin, and the young couple left immediately for St. Louis, Missouri, where he had an appointment in the Shaw School of Botany, Washington University. His work toward the doctor's degree was interrupted in 1892 when he accepted a position in the Section of Plant Pathology, U. S. Department of Agriculture, and was sent to Eustis, Florida, with Walter T. Swingle, to investigate diseases of citrus. His headquarters were transferred to Washington, D. C., in 1897, and although some studies on citrus were continued, his principal assignment was shifted to the field of plant breeding. In 1900 the degree, Doctor of Philosophy, was conferred on him by Washington University for work done in the Shaw School of Botany and the Missouri Botanical Garden and for his discoveries in connection with the spermatogenesis and fecundation of *Zamia*.

Dr. Webber was called to Cornell University in 1907 to organize and to become head professor of the Department of Experimental Plant Breeding. In 1912 he accepted an offer from the University of California to become Director of the Citrus Experiment Station at Riverside, California. During the year 1919-1920, Dr. Webber (and family) moved to Berkeley, where he became Director of the California Agri-

cultural Experiment Station. In 1920 he resigned his position with the University to become General Manager of the Pedigree Seed Company, Hartsville, South Carolina, but in 1921, he was recalled to the University of California with residence in Berkeley. He was appointed Professor of Subtropical Horticulture and Director of the Citrus Experiment Station, a post which he held until 1929. During the fiscal year



1924-1925, he took sabbatical leave to serve the governments of the Union of South Africa and Southern Rhodesia as a special commissioner to study and prepare a report on the citrus industry of those two countries. After completing their journey around the world, the Webbers removed to Riverside in 1926. Dr. Webber retired as Director of the Citrus Experiment Station in 1929, and in 1936, at the age of 70, he retired from active service. Mrs. Webber (deceased August 16, 1936) and Dr. Webber are survived by four children and nine grandchildren. The children are: (Mrs.) Eugene Frances (Webber) Morrison, (Mrs.) Fera Ella (Webber) Shear, Herbert Earl Webber, and John Milton Webber.

Dr. Webber contributed to the production of many crop plants. In Florida he worked on citrus, pineapples, and guavas; in Washington, D. C., on cotton, citrus, tobacco, corn and cowpeas; in New York, on oats, timothy hay, peppers, and Irish potatoes; and in California, on citrus, avocados, dates, lemon guavas, and feijoas. His published papers comprise a list of 263 entries, and cover the period, 1888 to

1946. Many fields of interest attracted his attention, with a definite concentration in his later years on the practical aspects of subtropical horticulture. His citrus work culminated in the publication of *The Citrus Industry*, edited by him, with Dr. L. D. Batchelor.

Dr. Webber's principal contribution to the date industry was his suggestion in 1923 that an institute for date growers be organized under the auspices of the Farm Bureau and the Agricultural Extension Service. He also suggested that the reports of the meetings should be published. Because of his enthusiasm and vision, he (1) was selected as the first speaker at the first Date Growers' Institute held on February 29, 1924. Dr. Webber (2, 3, 4, 5, 6) also contributed to several other programs, either in the role of chairman, or that of speaker. His last appearance was on April 24, 1943, when he served as chairman of the Twentieth Annual Date Growers' Institute.

It is entirely fitting and proper that the Date Growers' Institute should pause to honor the memory of Dr. H. J. Webber. The Institute has become one of the important horticultural societies of California, and the "Reports" comprise one of the principal sources of information on dates in the world.

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and

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Contributions by H. J. Webber to the Date Growers' Institute Annual Reports: (1) Program for improvement of date industry, 1:5-6, 1924; (2) (Remarks of the chairman,) 5:1, 1928; (3) (Remarks of the chairman,) 7:1, 1930; (4) Combination culture of dates and citrus, 10:5-7, 1933; (5) Stabilizing the date industry, 11:3-4, 1934; and (6) The outlook for the date, 12:3-4, 1935.

MICROBIOLOGICAL DETERIORATION OF DRIED FRUITS

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Consumer acceptance of dried fruits depends to a considerable extent on the moisture content of the finished product. When clean dried fruits of good quality are raised in moisture content from 20 or 25 per cent to approximately 30 per cent, the palatability, texture and appearance are improved. In addition to raising consumer acceptance, increasing the moisture content offers the added advantage of decreasing the possibility of "sugaring" on figs, dates and prunes. Increasing the moisture content, however, presents certain problems with respect to moisture loss and microbiological deterioration during storage of the packaged material. Moisture losses during storage are minimized by use of proper packaging materials and techniques. The control of microbial deterioration on the other hand requires the employment of sanitary procedures in the packing plant as well as special treatments at the time of packing.

Spoilage Organisms

Mold spoilage caused by *Aspergillus*, *Alternaria*, *Penicillium* and other common fungi is easily detected by the presence of mycelial growth as well as (apparent) undesirable tastes and odors. Yeast spoilage on the other hand is frequently more difficult to observe. It is usually caused by a group of yeasts peculiarly tolerant to high concentrations of sugar, in the range that occurs in dates and other dried fruits. They grow slowly causing fermentation of the sugars with gradual changes in flavor and structure of the tissue. The development of an undesirable flavor is accompanied by the formation of gas pockets, tissue breakdown and discoloration and skin ruptures. Several investigators have studied the yeasts responsible for these changes. Rodio (1924) observed the formation of a white crust in the wrinkles of the pericarp and particularly in the cracks of the epidermis and termed them *Zygosaccharomyces cavarae*. Later Beauverie (1929) isolated this organism as well as *Z. cavarae var beauverie* from Tunisian dates. Verona and Valleggi (1933) isolated *Hansenula fermentans* from dates. Esau and Cruess (1933) obtained two groups of yeasts from fermented California

dates; one termed *Saccharomyces* because of the alcohol forming power and the second termed torula yeast because of moderate production of alcohol. Melliger (1931) studied yeasts isolated from two distinct types of Egyptian dates which were characterized as follows: those containing insufficient sugar to prevent fermentation termed "amhat" and red dates containing sufficient sugar to prevent fermentation termed "hayami". Melliger obtained the amhat dates from markets in Marseille and Geneva, and hayami dates directly from Egypt. *Z. cavarae* and several unidentified species of *Zygosaccharomyces* and *Saccharomyces* were obtained from the amhat dates. *Hanseniaspora melligeri*, *Torulopsis pulcherrima* and some unidentified species of *Torula* and *Mycoderma* were isolated from hayami dates.

Fellers and Clague (1932) induced souring by placing pure cultures of yeasts isolated from "sour" dates in contact with sound pasteurized dates containing about 25 per cent moisture. In 1933 Clague and Fellers identified torulae with the "souring" of dates. In this case the souring referred to may well have been fermentation; for souring as such, (acetic acid formation) is not likely to be the result of independent action of yeasts but rather

an association between yeasts and acetic acid bacteria; or the independent activity of lactic acid bacteria.

Fellers (1930) and Clague (1936) made counts of yeasts occurring on dates and other dried fruits and in most instances found relatively few present. The fruits investigated in these cases were probably sound.

Mrak, Phaff and Vaughn (1942) examined 19 samples of California and two samples of Egyptian dates. Yeasts were obtained from the two Egyptian and 14 of the California samples. They isolated 67 cultures of yeasts most of which were species of *Zygosaccharomyces* and *Hanseniaspora*; although nine cultures of *Candida* and a few of *Pichia*, *Saccharomyces*, *Hansenula*, and *Torulopsis* were also found. All cultures of *Zygosaccharomyces*, except *Z. globiformis* grew in 66° Balling date syrup, whereas most of the others grew in 50°, but not 60° Balling syrup. See Table I.

Distribution of Spoilage Organisms

Yeasts, molds and bacteria can be expected to be present on dried fruit in considerable numbers when delivered to the packing plant. Unsanitary practice such as the use of dirty boxes or the mixing of spoiled with sound fruits favor an increased

Table I. Growth of Yeast Isolated from Dates in Various Concentrations of Date Syrup.

SPECIES	Number of Cultures	Concentration of Date Syrup (Degrees Balling)			
		40	50	60	66
<i>Zygosaccharomyces barkeri</i>	9	+	+	+	+
<i>Zygosaccharomyces japonicus var. saya</i>	20	+	+	+	+
<i>Zygosaccharomyces nadsanii</i>	1	+	+	+	+
<i>Zygosaccharomyces glabiformis</i>	1	+	+	±	—
<i>Saccharomyces carlsbergensis var. polymorphus</i> ..	1	+	±	—	—
<i>Saccharomyces cerevisiae</i>	1	+	±	—	—
<i>Hanseniaspora melligeri</i>	18	+	+	—	—
<i>Pichia chadati var. fermentans</i>	3	+	—	—	—
<i>Hansenula subpelliculosa</i>	1	+	+	±	—
<i>Candida chalmersi</i>	5	+	+	—	—
<i>Candida tropicalis</i>	2	+	—	—	—
<i>Candida krusei</i>	1	+	—	—	—
<i>Candida sp.</i>	1	+	±	—	—
<i>Torulopsis dactylifera</i>	3	+	+	—	—

Table II. Number of Mold Colonies Obtained from Field Run Deglet Noor Dates*

TIME OF SAMPLING	Number of Mold Spores		MOLD TYPES
	per gram	per date	
When delivered to the packing house	4,600	53,300	Chiefly <i>Alternaria</i> . <i>Penicillium</i> and <i>Aspergillus</i>
After 16 hours of fumigation with methyl bromide	2,900	36,000	<i>Aspergillus</i> and <i>Penicillium</i> Few <i>Alternaria</i>
At the end of shaker	100	1,400	<i>Aspergillus</i> and <i>Penicillium</i> Few <i>Alternaria</i>
At the end of the sorting belt	200	2,400	<i>Aspergillus</i> and <i>Penicillium</i> Few <i>Alternaria</i>

* Moisture content 26.6%.

population of these organisms, particularly yeast and bacteria. Table 2 gives an indication of the number of mold spores present on a particular lot of fruit which was followed through a plant. *Alternaria* was the most common type encountered prior to treatment with methyl bromide.

The change in mold population on dates in this particular test was in the favorable direction; but under less sanitary conditions the mold count on the fruit might very well increase as it moves through the packing plant.

Mold growth should not occur in packing plants if sanitary measures are used at all. Yeast and some bacteria on the other hand may increase to tremendous numbers in places where fruit sugars and moisture collect. Unclean boxes, sorting belts, packing tables, damp cloths or buckets of wash water will support large populations of yeast. Such places of microbial accumulation are responsible for much of the yeast and bacterial contamination on dates as well as figs and other dried fruits. It is essential that packing equipment be cleaned with an abundant supply of water and detergent at frequent intervals during the operating day. Accumulations of fruit particles on floors should also be removed frequently and the floor washed each day. Buckets of wash water should be eliminated and a system of continuous water flow installed. If damp

cloths must be used, then they should be treated in an effective detergent and the old cloths discarded and replaced by clean ones several times each day. An indication of the number of microorganisms occurring in wash water and damp cloths used in a dried fruit packing plant is given in Table III. It is obvious that fruits may become heavily contaminated at these points in a packing plant.

Prevention of Microbial Spoilage

The use of sound fruit and effective plant sanitation are essential in the production of superior quality dried fruit. Although treatment for killing molds, yeasts and most bacteria on dried fruits are available, these treatments do not improve the quality of the fruit at the time of treatment. They merely eliminate the possibility of spoilage or further spoilage if it has already started. Procedures, involving the use of heat or fumigation, may be used to destroy spoilage organisms and cold storage to retard their growth.

Clague and Fellers (1933) stated that pasteurization renders packaged dates free from the usual pathogenic and spoilage microorganisms and insects; and improves the appearance and flavor. Furthermore, they considered the operation commercially feasible. Temperatures, time and humidity conditions found effective in the pasteurization of dates are given in Table IV.

Table III. Number of Yeasts and Bacteria On Samples Collected In Dried Fruit Plant.

SAMPLE	NUMBER OF MICROORGANISMS
Wash water taken from container at packing table. Water used to wash hands.	184,000 bacteria per ml. 700 yeasts per ml.
Damp cloths used at sorting table	400,000,000 yeasts and bacteria per square inch.
Damp cloths used at cutting and trimming table	32,000,000 yeasts and bacteria per square inch.
Water from buckets used for washing hands	104,000,000 yeasts and bacteria per ml. About half were yeasts.

Table IV

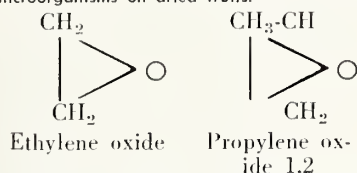
Time, Temperature and Humidity Conditions for Pasteurizing Dates (From Clague and Fellers, 1933).

Temperature, Degrees Centigrade	Time Minutes	Relative Humidity per cent
87	20	95 or above
82	30	75 or above
77	40	69 or above
71	50	90 or above
66	60	100
63	Na	effective pasteurizing time under 80 mins.

The pasteurization of foreign dates is practiced in the east with satisfactory results, although it is not used on California fruit. A serious objection to the use of pasteurization on sucrose dates such as produced to a large extent in California, is the tendency for them to darken when subjected to this treatment. Darkening caused by heat is not a serious factor in the case of imported dates. Experiments conducted by Sievers and Barger (1930) on the pasteurization of dates were said, by the authors, to be inconclusive. Nevertheless, indications were that the quality of fruit is better maintained by cold storage although the beneficial action of heat may control mold growth and destroy invertase.

The use of cold storage is one of the best means by which microbial spoilage can be retarded. It is difficult, however, to impress brokers and handlers of packed dates of the necessity of storing them at reduced temperatures until shortly before sold. Although holding dates in cold storage may prevent the growth of or even reduce the number of viable yeasts and molds present on the fruit, it will not result in sterilization. Dates removed from cold storage after a period of a year or more may mold and ferment when stored at room temperature for a few weeks. It is advantageous to accomplish killing of microorganisms on dried fruits having high moisture contents without the use of heat or cold storage. In this connection Mrak (1941) stated that *Zygosaccharomyces* obtained from dates could be killed with ethylene oxide or methyl bromide but the times and concentrations required are greater than those used for the control of insect infestation. Since then Whelton, Phaff, Mrak and Fisher (1946) have reported more fully on the control of yeasts and molds on dried fruits by fumigation with epoxide gases. Of the fumigants tested, the most successful were ethylene and propylene oxides. The structural formulae of these two fumigants are shown in figure 1.

FIG. 1. Epoxide fumigants used to control microorganisms on dried fruits.



Ethylene oxide has a boiling point of 51° F. and propylene oxide of 95° F. Boiling points of these compounds when mixed with isopropyl formate are given in Table V.

Table V
Boiling Points of Fumigation Mixtures.

EPOXIDE	% of epoxide in mixture with isopropyl formate	Boiling Point, Degrees F.
Ethylene oxide	10	118
	15	105
	20	92
Propylene oxide	25	136
	50	118
	100	95

The former is a gas at room temperature and because of this must be kept cool or mixed with a material having a higher boiling point if it is to be applied as a liquid. Propylene oxide is a liquid at room temperature but vaporizes rapidly unless kept cool. In order to reduce the vapor pressure ethylene oxide may be mixed with isopropyl formate or other non-toxic liquids with higher boiling points. This procedure comprises one step in the process patented by Baerwald (1945). These epoxides are very active compounds reacting with numerous substances present in the fruit. In aqueous solutions they are hydrolyzed to their respective glycols. In concentrations of from 3 to 80 per cent by volume, ethylene oxide forms an explosive mixture with air. To reduce the explosiveness it has been mixed with other materials as carbon dioxide. Although propylene oxide offers some fire hazard it is best used without mixing providing it is handled with care.

Whelton, et al. determined the concentrations of methyl bromide and epoxides, time and temperature required to kill organisms on freshly inoculated agar slants as shown in Table VI.

Table VI
Comparison of Fumigants.

FUMIGANTS	Organisms	Concentration MI/liter
Ethylene oxide, 20% in ethylene dichloride	yeasts	0.2
	molds	0.2
	bacterio	0.2
Propylene oxide	yeasts	0.3
	molds	0.3
	bacterio	0.6
Methyl bromide	yeasts	1.0
	molds	1.0
	bacterio	5.0

It is apparent that ethylene oxide is most effective and methyl bromide ineffective from a commercial point of view. Although less active than ethylene oxide, propylene oxide can be used to advantage as a commercial fumigant to prevent microbial deterioration of foods.

Time and temperature relation required to secure complete kills are shown in Table VII. Yeasts are killed more rapidly than molds.

Table VII
Effect of Temperature on the Time Required to Kill Yeasts and Molds by 20% Ethylene Oxide Mixture in Ethylene Dichloride.

(1 ml. per liter)		
Temperature° F.	TIME IN HOURS	
	Yeasts	Molds
50.0	3.0	5.0
55.4	2.0	4.5
60.8	2.0	4.0
66.2	1.5	4.0
77.0	1.5	3.5
86.0	1.5	2.5
93.2	1.0	1.5
98.6	1.0	1.5
104.0	0.75	1.5

In commercial application it is advisable to use one of the ethylene oxide mixtures listed in Table V or pure propylene oxide. The latter offers the advantages of a relatively high boiling point, though pure, and less toxic residues, according to Morris, Nelson and Calvery (1942).

Several methods of application under commercial conditions are possible but the most feasible involves use of an applicator in the packaging line. In such a line the applicator is designed to dispense a measured quantity of fumigating liquid into each package of fruit as it moves by. Applicators must be free of leaks, accurate, and dispense only when a package is in place to receive the fumigant. After the fumigant has been introduced into the package it is essential that it be sealed and placed in a case as soon as possible; likewise the case must be filled and sealed in the shortest time possible. Rapid sealing and casing is necessary to retard the loss of gas from the carton since several hours are required for complete killing. This procedure has been tried experimentally on dates, although hand rather than machine operated applicators were used. The results of these tests are given in Tables VIII, IX and X. Satisfactory results were obtained in all cases except when tried on packages of dates that had been in cold storage for at least a year. In this case the dates had become so tightly packed during storage that complete penetration of the gas failed to occur. Furthermore these packages were made

of poor materials and could not be satisfactorily sealed. If such dates are to be treated it would be wise to repack before fumigating.

The manner in which these gases act is uncertain although recent data indicate they may destroy certain enzyme systems. The fate of the fumigant is likewise uncertain. At one time it was presumed that most of it escaped from the package in the course of hours, or was converted to glycol. Because of the reactivity of these materials it would not be safe to preclude the possibility of other reactions.

Whelton, et al. (1946) have discussed the toxicology of ethylene and propylene oxides. When present in the air over long periods of time they may cause damage to the mucous membrane of the eyes and the respiratory tract. In view of this, when epoxide gases are used in a packing plant care must be taken to provide adequate ventilation.

As indicated above the fate of these gases in the presence of dried fruit is uncertain. If one assumes that the ethylene oxide present in packages of dried fruits is converted to ethylene glycol it would be necessary to ingest 1000 pounds of treated fruit to obtain the amount reported lethal. If the possible toxicity of ethylene oxide residues were in question it would be advisable, from this point of view, to fumigate with propylene oxide, the residue of which is non-toxic according to Morris, Nelson and Calvery (1942). However, there does not appear to be any justification for concern over this factor at present.

Limitations

Fumigation with epoxides has certain limitations. These gases are harmful when they persist in the air, hence adequate ventilation systems are essential. The concentration in the air or fumigation chamber must be held below 3 per cent, preferably by mixing with dry ice (9 pounds dry ice to each pound of ethylene oxide) to avoid fire and explosion hazard. Unsatisfactory results may be obtained unless treated cartons are sealed and cased immediately. Tightly packed fruit held in storage for a period of time, and then treated, may spoil in spite of the treatment because of failure of the gas to penetrate throughout the carton.

In order to obtain lasting results treated fruits must be in moisture proof containers. There is little reason to treat fruits with epoxides if they lose considerable moisture after a few months of storage.

Fumigation with epoxides will not improve the quality of the material

being treated, but will prevent deterioration caused by yeasts or molds or bacteria that may be present.

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TABLE VIII
Observations On Fumigated Dates

SERIAL NO.	VARIETY	TYPE	MOISTURE CONTENT OF DATES	WEIGHT OF 10 DATES (grams)	SIZE AND NUMBER OF BOXES TREATED	OBSERVATIONS AFTER 33 DAYS AT ROOM TEMPERATURE	
1-P	Moktum	High moisture likely to spoil under trode conditions	29.2%	108-125	8 oz. boxes of 280 ml. vol. 0.4 ml. propylene oxide box 5 boxes per cose; 2 coses checks, 2 coses treated	Treated, no spoilage	
1-C	"					Controls, sour	
2-P	Soidy	"	25.2%	152-172	box size ond treatment os above. 10 boxes per cose. 2 coses checks, 2 coses trtd.	Treated, no spoilage	
2-C	"					Controls, sour	
3-P	Deglet Noor	Green, moist ond very opt to spoil	25.7%	100-118	box size ond treatment os above. 9 boxes per cose. 2 coses checks, 2 coses trtd.	Treated, no spoilage	
3-C	"					Controls, very sour—much gos	
4-P	Hydroted Deglet Noor	Pocked immediately after hydroting	24.5%	108-118	10 oz. boxes of 400 ml. vol. 0.5 ml. propylene oxide/ box. 24 boxes per cose. 2 coses checks, 2 coses trtd.	Treated, no spoilage	
4-C						Controls, no spoilage	
5-P	Dote condy	Dote poste, orange peel & grope nuts meol rolled in bleoched corn flokes	22.6%		10 oz. boxes of 320 ml. vol. 0.5 ml. propylene oxide/ box. 24 boxes per cose. 2 coses checks, 2 cases trtd.	Treated, no spoilage	
5-C						Controls, no spoilage	
6-P	Khodrowi	High moisture dates which hod been held in cold storage 1 year	29.6%	112-117	23 coses treated with 3 ml. C ₃ H ₆ O per box	2½-lb. boxes of 1950 ml. vol. 12 boxes per cose	Treated with propylene oxide, no spoilage
6-F	"				26 coses treated with 1.5 ml. fumold per box		Treated with fumold, no spoilage
6-C	"				4 check coses		Controls, sour

P=Propylene oxide treated.

C=Control or check.

F=Fumold (commercial epoxide fumigant) treated.

TABLE IX. Effect of Propylene Oxide and Fumold on Microbiological Contamination of Dates.

SERIAL NO.	VARIETY	INITIAL COUNTS				*COUNTS AFTER 33 DAYS AT ROOM TEMPERATURE			
		Number of Yeasts		Number of Molds		Number of Yeasts		**Number of Bacteria	
		per gram	per date	per gram	per date	per gram	per date	per gram	per date
1-P	Moktum	3.5 x 10 ⁵	4.4 x 10 ⁶	0	0	0	0	7.9 x 10	8.9 x 10 ²
1-C	"	"	"	0	0	1.0 x 10 ⁷	1.1 x 10 ⁸	0	0
2-P	Soidy	5.6 x 10 ³	8.5 x 10 ⁴	±3.1 x 10 ³	4.7 x 10 ⁴	less than 10	less than 100	0	0
2-C	"	"	"	"	"	2.8 x 10 ⁶	4.6 x 10 ⁷	0	0
3-P	Deglet Noor	1.7 x 10 ³	2.0 x 10 ⁴	±2.5 x 10 ³	3.0 x 10 ⁴	less than 10	less than 100	0	0
3-C	"	"	"	"	"	7.1 x 10 ⁶	7.1 x 10 ⁷	0	0
4-P	Hydroted Deglet Noor	3.8 x 10 ²	4.1 x 10 ³	some A. niger		2.5 x 10	2.9 x 10 ²	0	0
4-C	"	"	"	" " "		less than 10	less than 100	0	0
5-P	Dote Condy	7.8 x 10 ⁴		0		less than 10		0	
5-C	"	"		0		2.5 x 10 ³		0	
6-P	Khodrowi	1.3 x 10 ⁴	1.5 x 10 ⁵	A. niger		0	0	4.4 x 10	4.9 x 10 ²
6-F	"	"	"	" "		3.2 x 10 ²	3.5 x 10 ³	0	0
6-C	"	"	"	" "		8.0 x 10 ⁵	9.2 x 10 ⁶	0	0

C = Controls

P = Propylene oxide treatment

F = Fumold treatment

** Bacterio were chiefly aerobic spore forming types.

* No molds found on wort or yeast glucose ogors.

± Chiefly Penicillio.

† Penicillio and A. niger.

Table X. Yeast Count on Dates After Ten Weeks of Storage at Room Temperature in Berkeley.

	SAMPLE	NUMBER OF YEASTS		REMARKS
		Per Gram	Per Date	
Moktum	1-P	0	0	all bxs. kept satisfactory
Soidy	2-P	1.8×10^3	2.9×10^4	all bxs. kept satisfactory
Green Deglet Noor	3-P	0	0	all bxs. kept satisfactory
Hydrated Deglet Noor	4-P	0	0	all bxs. kept satisfactory
Dote Condyl	5-P	0	0	all bxs. kept satisfactory
Dote Condyl	5-C	4.0×10^4	4.0×10^5	all bxs. kept satisfactory
Khadrowi	6-P	3.2×10^4	3.5×10^5	*two boxes slightly mold- ed; 8 boxes kept. satis- factorily.
Khadrowi	6-F	1.2×10^6	1.3×10^7	*two boxes fermented; 3 boxes mold-; 3 boxes kept satisfactory.

* Khadrowi dates were poked in 2½ pound kraft boxes which were lined with wax paper, but were not cellophane wrapped. Since they were not air tight the recontamination and subsequent spoilage can thus be accounted for.

P = Propylene oxide treatment

C = Control

F = Fumold treatment

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REMOVAL OF TALL DATE PALMS

By P. W. Van Der Meid

For the past twenty-three years the Date Institute has discussed problems pertaining to the growing, harvesting, and packing of California Dates. Today we are confronted with a new subject—that of disposing of date palms after they have reached a certain age and height.

The particular date garden referred to in this paper is a five-acre block of Deglet Noor Dates, known as the Model Date Garden. This planting consisted entirely of Yuma palms. For the benefit of some of the newer date growers who may be unfamiliar with the term "Yuma Palm," it might be stated that for several years beginning about 1917 Mr. C. E. Cook, father of Bill Cook, operated a nursery near Yuma, Arizona. There the shoots were planted and left to grow for four or five years. When transplanted to the Coachella Valley they were quite a good sized palm, weighing around 1500 pounds and having many offshoots attached. Back in the days when these palms were brought in we had none of the modern machinery which we have today, which meant that the loading, unloading, and planting had to be done by main strength and awkwardness. In the case of this particular planting, it is the writer's belief that these palms were not set out to a sufficient depth. During the next few years after this planting was made all of the offshoots were removed,

which had a tendency to weaken the base.

By February 1946, 28 years after planting, these palms had reached a height of 50 feet to the crown. It should be borne in mind that they were several years old when transplanted, therefore, their growth would be about equal to a palm which had been set out for about 32 years from a normal shoot. Many of these palms were leaning very badly in spite of efforts to hold them upright with timbers and cables. It was felt impractical to use a moving platform or tower on account of the many braces and cables which obstructed the drive between the rows. These palms had always been well cared for and while they were still producing heavily of good quality fruit, it was decided to remove them from the standpoint of safety. At the prevailing date prices the increased cost of operation was not the deciding factor. It was almost impossible to induce men to work in these high palms.

Now as to the method employed to remove these palms. Mother Nature aided somewhat during a heavy windstorm. However, when a palm was blown down it generally broke off at the ground leaving all the roots in the ground. At times, after a heavy irrigation, a palm would fall, taking with it most of the ball, or root system. Since it is de-

sirable to remove the ball of roots from below ground level, a large bull-dozer was employed. This machine gouged out a hole about four to five feet deep on one side of the palm, then by pushing from the opposite side the palm was brought down, taking the ball of roots along with it. It might be stated that the garden was very thoroughly irrigated before-hand, in order to soften the ground around the roots. The cost of this operation was most reasonable. This machine could accomplish in five minutes the work required of several men working hard for several hours. After a palm had fallen it was pushed by the bull-dozer to the rear of the property, where two windrows were formed. A total of 200 was removed at a cost of \$450, or an average of \$2.25 per palm. This also included the cost of filling up the holes and levelling the ground.

There are still many Yuma palms or original importations growing in the Coachella Valley which are producing heavily. Naturally, the cost of production increases with the very tall palms and the advisability of carrying on depends upon the net returns. However, most of these palms have reached a point where unless some modern method is developed so that they may be worked economically and with safety, it may soon be necessary to remove them.

THE ARKELL DATE GARDEN FERTILIZER EXPERIMENT*

By Donald E. Bliss and Forrest Mathez**

The maintenance and improvement of soil fertility are problems of great importance to the date industry, as well as to agriculture in general. In the Old World, where dates have been grown for hundreds of years, animal manures have long been used for the enrichment of orchard soils. In the valleys of the Nile (17) and of the Shatt al Arab (7), the deposition of silt is said to have also increased the fertility of agricultural lands.

From the available reports of fertilizer practices in the date-growing countries of the Old World, most of which were written more than twenty years ago, it appears that the use of chemical fertilizers in those countries is practically unknown, and that the practice of intercropping with leguminous plants is uncommon. Kearney (15) attributes the low nitrogen content of date soils in Tunis to the scarcity of animal manures, the continual irrigation of the oases, and the small extent to which leguminous crops are grown among the palms. Dowson (7), in his description of date culture in Al 'Iraq, states that with the exception of gardens on the right bank of the Shatt al Arab and those near Baghdad, very few gardens in that country are manured. In those gardens, manure at the rate of three tons per acre is mixed with the topsoil and turned under to a depth of about four feet every fourth year. According to Dowson (8), the average yield of date palms in Al 'Iraq in 1919 was 44 pounds per palm, or about 5,000 pounds per acre. Popenoe (25) states that twice a year the Arabian Fardh growers at Oman work into the soil a donkey load per tree of well-rotted manure and straw. In India soil fertilization is not regularly practiced, although Milne (20) observed very much increase in the vigor and growth rate of young palms and in the fruit-bearing capacity of adult palms where manure was applied. Brown

(3) states that in Egypt the necessity of manuring the trees is generally recognized by cultivators. A common method of application is that of placing manure in a pit on one side of the palm, to the depth of the underground water table.

In the United States the date growers have fertilized their orchard soils with animal manures and, in recent years, have also applied chemical fertilizers. Various leguminous plants are grown in many gardens as winter cover crops. These practices have developed principally for the purpose of supplementing the supplies of nitrogen and organic matter in the soil.

Swingle (29), in 1904, noted the relatively large proportion of useful plant foods, especially sodium nitrate and potassium chloride, in the alkali of the Salton Basin. He predicted that these salts would render the soils very fertile to any plant which, like the date palm, can withstand a considerable percentage of alkali in the soil.

The utilization of inorganic nutrients by the date palm was studied by Haas and Bliss (11), who calculated from analyses that the mature dates on a Deglet Noor palm with 9,000 fruits contain 0.528 pounds of nitrogen, 0.0903 pounds of phosphorus, and 1.294 pounds of potassium. Haas (10) points out that the inorganic content of dates is important because these constituents are lost to the palm when the crop is harvested.

Up to the present time, there has been very little if any direct experimental evidence of the effect of soil fertilization on the date palm. In the United States, as in other date-growing countries, the practice of soil fertilization has become established through the practical experience of the date growers. Haywood (12) was among the first in this country to demonstrate the high yielding capacity of Deglet Noor palms following heavy applications of animal manure, chemical fertilizers, and green manure crops. Several other date growers (4, 5, 6, 9, 14, 18, 24) have discussed soil fertilization of date orchards in the light of their personal experiences. Animal manures, at the rate of 6 to 12 tons per acre, and various chemical fertilizers were being applied by these growers. Richardson (26), in 1941, concluded that date growers in the Coachella Valley spent, on the average, about \$25 per acre

annually for fertilizers. The heaviest users of manure, in Richardson's opinion, seemed to have the largest yields and the crops of best quality.

In 1935, the late James Arkell (2), of the Indian Wells district, about eight miles west of Indio, California, called on Dr. L. D. Batchelor, Director of the University of California Citrus Experiment Station, at Riverside, for assistance in conducting a simple fertilizer experiment in his orchard of young Deglet Noor palms. Mr. Arkell was not satisfied with the quality of the dates that were being produced, and was hopeful that the trouble might be corrected by means of fertilizers. Accordingly, an informal cooperative project was started in February, 1935, with Mr. Arkell furnishing the materials and the labor in the orchard, the California Date Growers Association grading and processing the fruit in the packing house, and the University of California acting in an advisory capacity. Mrs. Nelle Carpenter Foltz, whose date orchard adjoined the Arkell property, kindly permitted the use of certain palms in her orchard for the establishment of control plots. Though interrupted in 1944 by the war, this project was continued long enough to give Mr. Arkell much valuable information toward the improvement of date yields and quality in his orchard.

It is the purpose of the present paper to report to the date industry the results obtained in the Arkell date garden fertilizer experiment, and to discuss some of the problems involved in such an experiment. Although incomplete in certain respects, this is perhaps the first controlled experiment on date fertilization to be recorded in the literature.

Materials and Methods

This simple fertilizer experiment, which was planned by L. D. Batchelor, E. R. Parker, and D. E. Bliss, included 14 test plots in a block of six-year-old Deglet Noor palms (fig. 1). Two test plots were used for each of five different fertilizer treatments and for each of two controls which received no treatment. Plots having the same fertilizer treatment were separated as widely as possible, and one plot of each pair, except of that including plots 6 and 12, occupied a portion of three rows of palms along the south edge

* Paper No. 546, University of California Citrus Experiment Station, Riverside, California.

** The writers are especially indebted to the late James Arkell for his interest and financial aid in this experiment. They wish, also, to express their appreciation to Arthur Cavanaugh, Donald Mitchell, and the Staff of the California Date Growers Association for assistance; and to L. D. Batchelor, W. B. Sinclair, A. R. C. Haas, E. R. Parker, Ray W. Nixon, and H. L. Cavanaugh for technical advice.

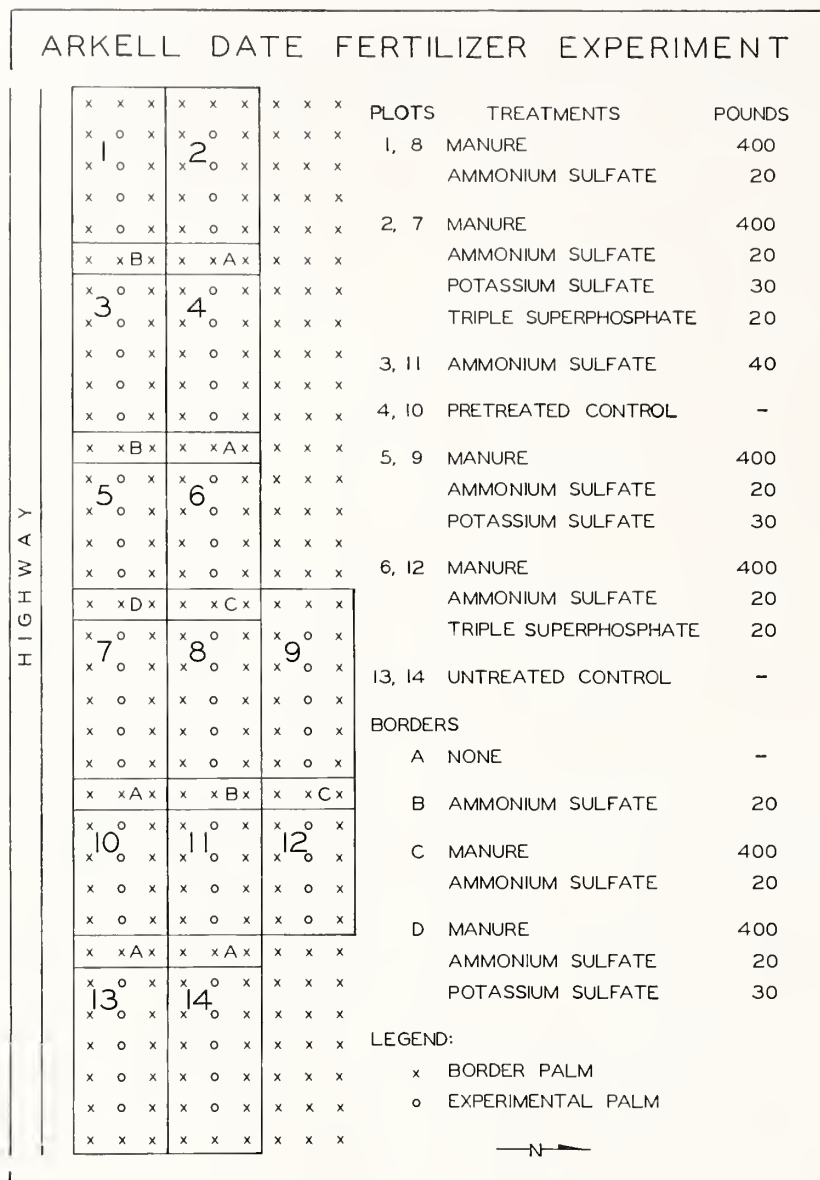


Fig. 1.—Plot plan and soil treatments, Arkell date garden fertilizer experiment.

of the orchard, adjoining the highway.

All the fertilized plots were supplied with nitrogen in the form of ammonium sulfate, each palm in plots 3 and 11 receiving 40 pounds of ammonium sulfate annually, and each palm in the other eight plots receiving 20 pounds of ammonium sulfate plus 400 pounds of Imperial Valley dairy manure annually. Plots 5 and 9 also received annual applications of 30 pounds of potassium sulfate per palm, and plots 6 and 12 received 20 pounds of triple superphosphate per palm, while plots 2 and 7 received both potassium sulfate and triple superphosphate in the stated amounts. Because of the wartime shortages of chemical fertilizers, uramon was substituted for ammonium sulfate in 1940 and 1941,

and triple superphosphate was omitted in 1943.

The manure, potassium sulfate, triple superphosphate, and one third of the ammonium sulfate were broadcast in the irrigation basins and disked under with the weeds in late winter. No cover crops were planted, and none of the leaf prunings were returned to the soil. One half of the remaining ammonium sulfate was applied in the spring, and the other half in the summer.

In the Arkell orchard plots (Nos. 1 to 12, inclusive), manure had been applied at the rate of 25 tons per acre, both in 1934 and in 1935, before the beginning of the experimental treatments. A poor, weedy cover crop had also been grown in 1934. Because of the treatment received in 1934 and 1935, control plots 4 and 10 in this orchard are

termed "pretreated." Control plots 13 and 14, in the Foltz orchard, which received no fertilizer treatment from the time of planting until the close of the experiment, are termed "untreated."

The experimental orchard, which sloped from west to east, had been graded on six levels in such a manner as to form broad terraces that would permit basin irrigation. The terraces, extending across the orchard from north to south, included groups of five or six palms from each row. Each fertilizer plot included three adjacent rows of palms on the same terrace. The entire plot received the same fertilizer treatment, but only four or five palms, standing in the middle row, could be used for experimental purposes (fig. 1). Some of the wide-spreading roots of all other (border) palms could probably have been traced into soil of another plot. The fertilizer treatment of soil about border palms at the west end of each plot included only materials that were common to the treatments on either side of the boundary. The trunks of experimental palms were thus separated from soil containing different fertilizers by a distance of 45 feet, since the palms had been planted at the corners of 30-foot squares.

Irrigation water was obtained principally from a deep well situated a quarter of a mile west of the experimental plots, and occasionally (for plots 1 to 4, inclusive) from a shallow well near the northwest corner of the plots. Chemical analyses of water from these wells are reported by Huberty, Pillsbury, and Sokoloff (13), who found the nitrate content of the water to be as follows (table 1): from the deep well (5-6-22c), 0.08 to 0.60 milliequivalents per liter, or 13.2 to 100.5 pounds per acre-foot; and from the shallow well (5-6-22b), 1.20 to 1.24 milliequivalents per liter, or 201.1 to 207.8 pounds per acre-foot. Analyses of recently collected samples, by B. M. Laurance and G. F. Liebig of this station, show a nitrate content of 16.5 pounds per acre-foot of water from the deep well and 1313.9 to 1359.1 pounds per acre-foot of water from the shallow well (table 1). The total amount of irrigation water applied per year to the fertilizer plots is estimated to have been about 15 acre-feet per acre, the intervals between irrigations varying from about 7 to 10 days during the hottest weather, to about 6 weeks in winter. At this rate, on the basis of the most recent analyses, the water from the deep well supplied approximately 5.15 pounds of nitrate per palm per year.

The soil of the fertilizer plots was mostly Coachella fine sand, ex-

TABLE 1.—Nitrate Content of Water from Wells Used in Irrigating Plots of the Arkell Date Garden Fertilizer Experiments, as Indicated by Chemical Analyses.

WELL NO.* AND LOCATION IN SECTION	Total Well Depth (feet)	DEPTH TO WATER			Date Sample Collected	NITRATE (NO ₃) CONTENT	
		Static (feet)	Pump (feet)	Discharge (c.f.s.)		Milligram Equivalents Per Liter	Pounds Per Acre-Foot
5-6-22c† (Ctr. W side, SW ¼ of NE¼).....	503	63	74	1.7	7-13-38	0.60‡	100.5
					11-17-38	0.08‡	13.2
					1-14-39	0.10‡	16.5
					4- 8-46	0.10§	16.5
					7-13-38	1.20‡	201.1
5-6-22b (Nr. SE cor. SW ¼ of NE ¼).....	143	61	83	0.5	11-17-38	1.24‡	207.8
					4- 8-46	7.84§	1313.9
					5- 7-46	8.11§	1359.1

* Well numbers designate township, range, and section.

† Experimental fertilizer plots irrigated principally with water from this well, 5-6-22c.

‡ Data from Huberty, Pillsbury, and Sokoloff (13).

§ Analyses by B. M. Lourance and George F. Liebig.

cept at the eastern end (plots 13 and 14), where it was Coachella very fine sand (16). On January 11, 1940, at one station in plot 7, the moisture equivalent and soil reaction at different depth intervals were as follows (1):

Depth Interval of Soil (in ft.)	Moisture Equivalent (per cent)	Soil Reaction*	
		At Field Moisture Content (pH)	At 1:5 Soil- Water Ratio (pH)
0.0-0.5	9.5	7.60	8.71
0.5-1.0	9.5	7.90	9.10
1.0-2.0	9.7	7.91	9.17
2.0-3.0	9.9	7.86	9.17
3.0-4.0	6.6	7.90	9.00

* Determinations by A. R. C. Hoos.

The pH values of the soil in plots 8, 10, and 11 were similar to those shown above. Undeveloped mesquite land nearby had a reaction of pH 7.51 from 0.0- to 1.0-foot depth, and of pH 7.11 from 1.0- to 1.5-foot depth, when measured at field moisture content.

The experiment at Arkell's was originally organized to study the effect of different soil fertilizers on the yield and quality of Deglet Noor dates. The management of the experimental orchard was to be as uniform as possible, while soil fertilization was to be varied as previously described. The palms were to be allowed to bear as heavily as they would under the then preferred practices of fruit thinning and leaf pruning, fruit thinning being done on a percentage basis, as suggested by Nixon (21), without special regard for leaf area, and the older green leaves being pruned every year to allow all fruit bunches to hang free below the top. The results of the experiments were to be taken from packing-house records of weights and grade separations.

In the freeze of 1937, all the exposed leaves in the orchard were killed or injured, and the green-leaf area of the palms was consequently reduced 80 or 90 per cent.

The number of fruit bunches for that year was arbitrarily reduced to four per palm. Most of the palms were strong enough to bear fruit in 1938, and in 1939 recovery appeared to be so satisfactory that 80 per cent of the fruit bunches and 45 per cent of the fruits on these bunches (35.7 to 38.5 per cent of all fruits) were retained. Unfortunately, many of the palms were later found to be overloaded, and the dates that year were small. In 1940, many of the palms were found to be affected with alternate bearing, the number of spathes on these palms being greatly reduced. By this time Nixon (22) had determined that an average of 7.5 leaves per fruit bunch was desirable in order to obtain proper balance in the palm.

In attempting to avoid alternate bearing in the fertilizer experiment, we retained, in 1940, a maximum of 125 fruits per green leaf (18). The young fruits were distributed on as many different fruit bunches as necessary. Most bunches were thinned to 1200 fruits or less, and the maximum number of fruits for any bunch was 1400. No limits were placed on the total production of a palm. Our later records indicated, however, that alternate bearing had not been eliminated entirely by this method, and that it still persisted in palms having small leaves or small total leaf area. The different responses of the experimental palms indicated that the total leaf area, not the number of leaves, was of fundamental importance in calculating fruit load and in controlling alternate bearing (19). At that stage of the investigation, we thought 91 mature green leaves was the maximum number that could be retained on a palm during harvest season without interfering too much with the fruit, but we suggested (19) that during the spring and early summer months as many green leaves be retained as possible. Our data indicated that a Deglet Noor palm having 104 to 115 mature green leaves, exclusive of

the immature leaves about the growth center, with an average leaf area of 47.1 sq. ft. at the time of fruit thinning, was capable of bearing 125 fruits per leaf without danger of alternate bearing; that a palm with 91 to 103 leaves (44.3 sq. ft. average area) was capable of bearing 118 fruits per leaf; and that a palm with 78 to 90 leaves (42.9 sq. ft. average area) was capable of bearing 100 fruits per leaf.

Beginning in 1942, the experimental palms were allowed to carry throughout the year as many green leaves as possible. The only leaves removed were those that were dying. This method, which has also been used by Nixon (23), allowed the most vigorous palms to carry about 150 green leaves. Interference with fruit-bunch management was less than had been expected, and the fruit-bearing capacity was increased considerably.

The fruit-thinning method used at present (1946) at Arkell's was developed for the express purpose of retaining the maximum number of dates that could be successfully matured in one crop without producing alternate bearing. According to this method, the desired total number of dates is calculated from the green-leaf area of the palm, as already explained. Special effort is made in the preliminary stage of thinning, to pollinate and to retain a number of dates well in excess of the actual number desired for ripening. This precaution is taken to allow for possible exigencies such as off-bloom, poor pollination, excessive June drop, etc. At the time of pollination, there is no reduction of small fruit bunches; the fruit-strands of medium-sized bunches may be shortened slightly, and large bunches (those with 50 to 100 fruit-strands) may be shortened to about 50 or 60 fruits per strand and reduced to about 40 strands by entirely removing the strands at the center. The severity of this initial thinning varies according to the

number of spathes emerging. In the final stage of fruit thinning, which takes place late in June after the fruit set and the amount of June drop are known, the desired total number of dates for the palm is distributed among as many fruit bunches as necessary, the attempt being made always to retain bunches with at least 1050 dates each, but never more than 1400 dates each. Bunches with less than 1050 dates are retained if necessary to make the desired fruit load. The fruit-strands should carry about 35 fruits each, although 40 fruits are permissible on the largest bunches. Desirable fruit-thinning formulae range from 30 x 35 (1050 fruits) to 40 x 35 (1400 fruits), the number of strands and the number of fruits per strand being interchangeable according to the circumstances. This method requires close supervision, since much discretion must be placed in the hands of the supervisor. It is our experience that fruit thinning by the so-called percentage method results usually in a shortage of fruit in years of off-bloom, poor pollination, or heavy June drop. The Arkell method minimizes this danger.

Except for the thinning procedure, the experimental fruit was managed according to recognized practices: Wire rings were inserted in the fruit bunches in midsummer to increase aeration, and paper fruit protectors (bags) were installed in August to protect the dates against rain and birds. The dates were picked at 2- to 3-week intervals as they ripened, from October to February, except in the later years, when the number of fruit pickings was decreased because of the wartime labor shortage. At times of picking, all fruit from the experimental palms in one plot was brought together in one lot. The various lots were labeled and hauled to the packing house, where they were weighed and graded separately. The records of these weights and grade separations constituted the principal data on the quantity and quality of fruit produced. Unfortunately, the dates that were left under the palms, that were lost from spoilage, shattering, or accidental dropping, were not counted. In 1939 and 1941, this loss was considerable.

Increments in trunk elongation of all experimental palms were measured at yearly intervals, from 1936 to 1944. Measurements were made with a steel tape to determine the distance from a permanent bench mark on the side of the trunk to the uppermost fiber line. The composition of dates from the different test plots was studied in 1940 by Sinclair, Bartholomew, and Bliss (27).

and inorganic chemical analyses of the same samples were made by Sinclair and Ramsey (unpublished).

Weather Conditions

Although extensive weather records for the Arkell orchard are not available, certain extreme conditions that had great effect on the yield and quality of fruit produced were noted from 1935 to 1943. Minimum air temperatures of 14° to 20° F. were recorded by a thermograph in the orchard on five days in January, 1937. The total duration of temperatures of 20° or below was

about 20 hours. All the exposed leaves on the palms were killed or severely injured, and the green-leaf area was reduced 80 to 90 per cent. Four to five years were required for the development of enough new leaves to replace the ones that had been destroyed. Pinnæ on the more exposed leaves were again injured on January 19, 1943, when the air temperature fell to about 20°.

Unusually rainy weather in September, 1939, was accompanied by fruit spoilage (water injury, fungus rots, and insect injury) amounting to 42 per cent of the estimated ton-

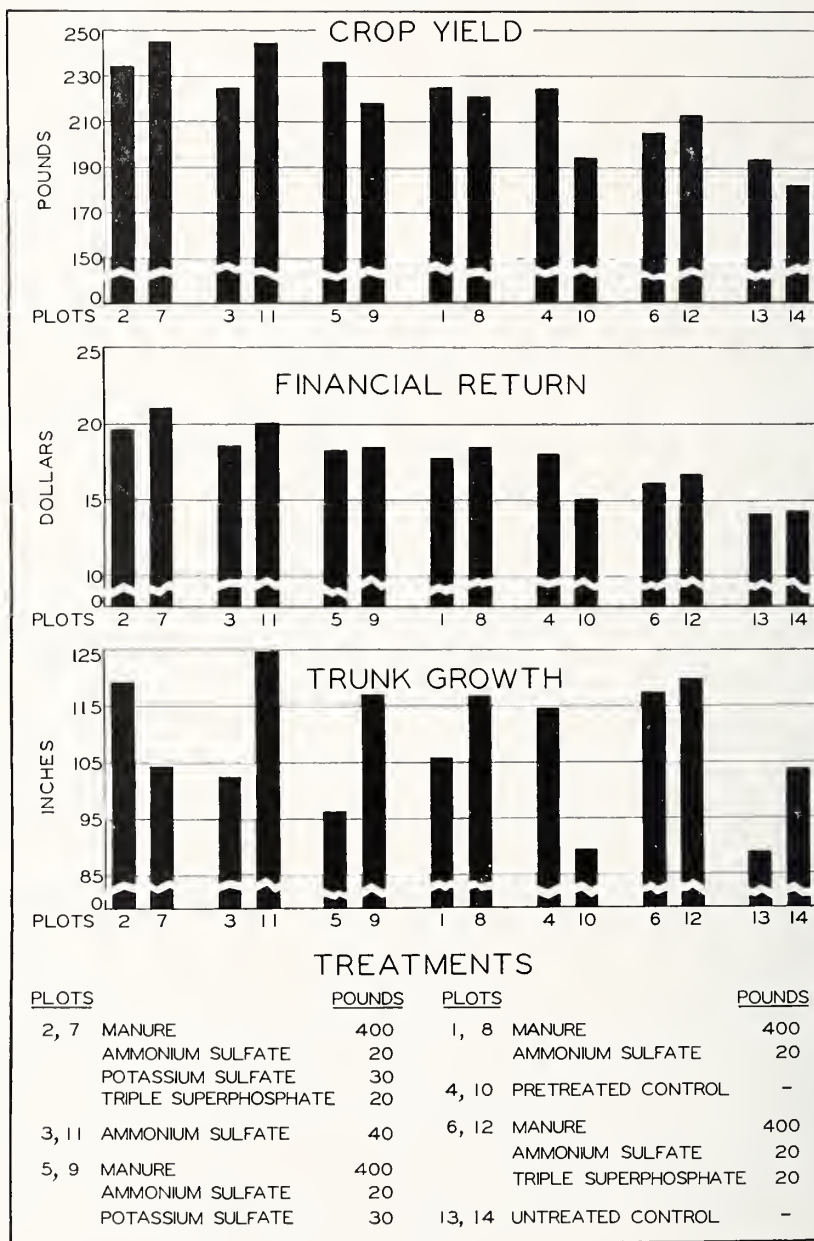


Fig. 2.—Results of the Arkell date garden fertilizer experiment, 1939-1942, inclusive: CROP YIELD, or mean yield of dates per palm per year; FINANCIAL RETURN, or mean gross return per palm per year, based on the mean prices paid by the California Date Growers Association to members for Deglet Noor dates; and TRUNK GROWTH, or mean trunk elongation per palm, June, 1938 to June, 1942.

TABLE 2.—Mean Annual Yield Per Palm, and Percentage Composition of Grade Separations, Arkell Date Garden Fertilizer Experiment, 1939 to 1942, Inclusive.

FERTILIZER TREATMENT AND AMOUNT OF MATERIAL PER PALM PER YEAR	PLOT No.	Mean Annual Yield Per Palm (lbs.)	GRADE SEPARATIONS* (per cent)					
			A	B1	B2	C	D	Culls
Manure, 400 lbs.; ammonium sulfate, 20 lbs.; potassium sulfate, 30 lbs.; triple super- phosphate, 20 lbs.	2	234.2	1.8	17.1	54.4	4.6	10.7	11.4
	7	244.9	0.2	5.4	55.0	13.9	17.6	7.9
Ammonium sulfate, 40 lbs.	3	225.3	0.4	7.2	58.3	13.6	12.0	8.5
	11	244.5	1.2	13.1	59.5	4.8	9.6	11.8
Manure, 400 lbs.; ammonium sulfate, 20 lbs.; potassium sulfate, 30 lbs.	5	236.2	0.1	4.3	51.2	10.7	27.0	6.7
	9	218.4	1.0	15.9	62.0	4.6	5.9	10.6
Manure, 400 lbs.; ammonium sulfate, 20 lbs.	1	225.1	0.2	6.0	56.2	9.0	20.7	7.9
	8	221.1	1.8	13.2	59.0	6.9	7.5	11.6
None (pretreated control)	4	224.7	0.9	11.6	59.9	2.9	13.2	11.5
	10	194.0	0.1	2.1	50.1	16.6	24.0	7.1
Manure, 400 lbs.; ammonium sulfate, 20 lbs.; triple superphosphate, 20 lbs.	6	204.7	0.2	11.1	61.0	6.1	8.0	13.6
	12	212.6	1.0	13.5	60.4	3.4	8.2	13.5
None (untreated control)	13	193.3	0.1	1.7	38.5	15.8	35.8	8.1
	14	182.2	0.7	10.6	47.5	9.8	20.9	10.5
Average deviation from mean		15.3	0.5	4.3	4.9	4.0	7.3	2.0

* Standard grades: A (Extra Fancy), B1 (Fancy), B2 (Star Choice, Standard), C (Dry).
Substandard grades: D, (by-products), Culls (nonedible).

nage. In 1941 about one fourth of the crop was lost from spoilage following a series of light rainstorms in late summer and fall. The most favorable weather for fruit production occurred in 1940 and 1942.

Results

YIELD OF FRUIT.—Although the weights of fruit delivered to the packing house were recorded each year from 1935 to 1943, inclusive, the only yield records of this kind worthy of publication were obtained during a period of four years, 1939 to 1942, inclusive. Yield data in 1935 and 1936 were thought to be of little value owing to the newness of the differential soil treatments; those in 1937 and 1938 were comparatively worthless because of severe bunch thinning following the freeze of 1937; and the yield data from the crop of 1943 had to be discarded because of certain obvious discrepancies. The yield records even during the period 1939-1942 are open to criticism for the following reasons: (a) the experimental palms had not fully recovered from the freeze of 1937, (b) alternate bearing had not been entirely controlled, and (c) considerable loss in tonnage from fruit spoilage in 1939 and 1941 was not included in the packing-house records. Despite these limitations, the data from the different test plots are comparable and they give an approximate indication of the fruit-bearing capacity of the experimental palms during this period.

When the experimental plots were paired according to soil fertilizer treatment (fig. 2), plots 2 and 7 had the highest mean yields of dates per palm per year during the period 1939-1942, and plots 13

and 14 had the lowest. The yields ranged from 244.9 pounds per palm in plot 7 to only 182.2 pounds per palm in plot 14. The yields in plots 2 and 7, where manure, ammonium sulfate, potassium sulfate, and triple superphosphate had been applied, were only slightly higher than those in plots 3 and 11, where ammonium sulfate alone had been applied. (The ammonium sulfate treatment had given marked stimulation in yield the first year of the experiment). Wide variation occurred in the yields of pretreated control plots 4 and 10; whereas the yield per palm in plot 10 was about equal to that in untreated control plots 13 and 14, the yield per palm in plot 4 was remarkably high, being greater than that in treated plots 6, 8, 9, and 12, respectively.

FINANCIAL RETURN.—The mean prices paid by the California Date Growers Association to members for Deglet Noor dates in the crop years 1939-1942 were as follows:

GRADE SEPARATION	Mean Price Per Pound
Standard grades:	
A (Extra Fancy)	\$0.2017
B1 (Fancy)	0.1216
B2 (Star Choice, Stand- crd)	0.0905
C (Dry)	0.0991
Substandard grades:	
D (by-products)	0.0576
Culls (nonedible)	- 0.0025

The application of these mean prices to the grade separations of the lots of experimental fruit showed a gross financial return per palm per year, 1939 to 1942, inclusive, ranging from \$21.02 in plot 7 to only \$14.11 in plot 13 (fig 2). The soil fertilizer treatments had affected financial returns in much

the same manner as they had affected crop yields. Some differences in fruit quality were indicated by the percentage composition of grade separations (table 2), but under the conditions of this experiment, crop yield was considerably more important than fruit quality in determining financial return.

TRUNK GROWTH.—Mean trunk growth (elongation) per palm, from June, 1938, to June, 1942, ranged from 124.8 inches in plot 11 to only 89.6 inches in plot 13 (fig 2). The elongation of the trunks was apparently affected by factors other than soil fertilizer treatment, because in plots 1, 3, 5, 7, 10, and 13, all adjacent to the highway (fig. 1), the mean growth was 98.1 inches during this four-year period, while that in the other eight plots was 116.8 inches. The reason for this difference is not understood, but such factors as light intensity and temperature may have had some effect. When the plots adjacent to the highway are excluded, the effect of soil fertilization can be seen (table 3). Mean annual trunk growth was greatest in plot 11, where ammonium sulfate had been used; it was least in the control plots, and was intermediate in the other fertilized plots. Trunk growth seemed to be closely related to nitrogen fertilization, but was not closely related to crop yield. The plots near the highway yielded as much fruit per palm as those in which trunk growth was more rapid, and in some cases they yielded more.

The rate of trunk elongation in palms of this experiment was generally found to be more rapid from 1936 to 1941 than from 1941 to 1944 (fig. 3). The palms grew more rapidly from seven to twelve years

TABLE 3.—Mean Annual Trunk Growth (Elongation) of Palms, Arkell Date Garden Fertilizer Experiment, June, 1938, to June, 1942, Inclusive.*

PLOT No.	FERTILIZER TREATMENT AND AMOUNT OF MATERIAL APPLIED PER PALM PER YEAR	Number of Palms	Mean Annual Trunk Growth (inches)
11	Ammonium sulfate, 40 lbs.....	4	31.14
2	Manure, 400 lbs.; ammonium sulfate, 20 lbs.; potassium sulfate, 30 lbs.; triple superphosphate 20 lbs.	4	29.83
6, 12	Manure, 400 lbs.; ammonium sulfate, 20 lbs.; triple superphosphate, 20 lbs.....	8	29.71
9	Manure, 400 lbs.; ammonium sulfate, 20 lbs.; potassium sulfate, 30 lbs.....	5	29.30
8	Manure, 400 lbs.; ammonium sulfate, 20 lbs.....	5	29.25
4	None (pretreated control).....	5	28.65
14	None (untreated control).....	5	26.00

* Data omitted for plots 1, 3, 5, 7, 10, and 13, all of which were situated adjacent to the highway. Reasons for these omissions are discussed in the text.

of age than from twelve to fifteen years of age. This trend seems to agree with observational evidence that the normal growth curve of the date trunk is sigmoid, that is, the growth rate is slow at first, becomes rapid for a few years, and finally decreases gradually with age. Years seven to twelve, inclusive, apparently included a part or all of the most rapid growth phase, while in years

thirteen to fifteen the growth rate showed slight deceleration. During 1937, 1938, and 1939, when the trunks were measured twice a year, the growth rate was usually more rapid from May to January than from January to May. The maximum leaf development on these palms did not occur until after the rate of trunk elongation had begun to decelerate.

Discussion

Soil fertility in the Arkell plots was such that none of the palms had, or developed, acute symptoms of mineral deficiency at any time during the experiment. The irrigation water, like that in other parts of the Indian Wells district of the Coachella Valley, has an unusually high nitrogen content. Mr. L. V. Wilcox (in a letter dated April 8, 1946, to D. E. Bliss) reports analyses of five wells in Township 5S, Range 6E, in which the Arkell orchard is situated. The nitrate (NO_3) in these waters ranged from 0.04 to 1.33 equivalents per million (milligram equivalents per liter). Huberty, Pillsbury, and Sokoloff (13) report 23 analyses from 18 different wells in the township. The nitrate in these waters ranged from 0.00 to 3.37 e.p.m., and the mean value was 0.83 e.p.m. (139.6 pounds per acre-foot of water). This high nitrate content, found especially in the shallow wells, was attributed (13) to litter of high nitrogen content which had accumulated under the forests of large mesquite trees originally covering most of this area. It is supposed that when the land was cleared and placed under irrigation, this litter underwent rapid decomposition, and that some of the soluble salts, including the nitrates, were leached downward to the underground waters.

Huberty, Pillsbury, and Sokoloff (13) also analyzed virgin soil from two stations an eighth of a mile east of the experimental plots. Soil samples were taken to a depth of 9 feet in a mesquite-covered area and in a near-by sagebrush area. One-to-five aqueous extracts of these soil samples showed the following amounts of nitrate (NO_3) present (13):

Soil-Sample Depth (feet)	Mesquite Area (m.e./kg.)	Sagebrush area (m.e./kg.)
0-1	5.1	7.9
1-2	24.9*	10.7
2-3	9.3	9.7
3-4	16.4	5.5
4-5	15.7	4.0
5-6	7.4	4.0
6-7	7.1	3.2
7-8	9.6	0.9
8-9	4.5	.....

* This represents about 630 pounds of nitrogen (2790 pounds of nitrate) per acre-foot of soil, an extremely high value.

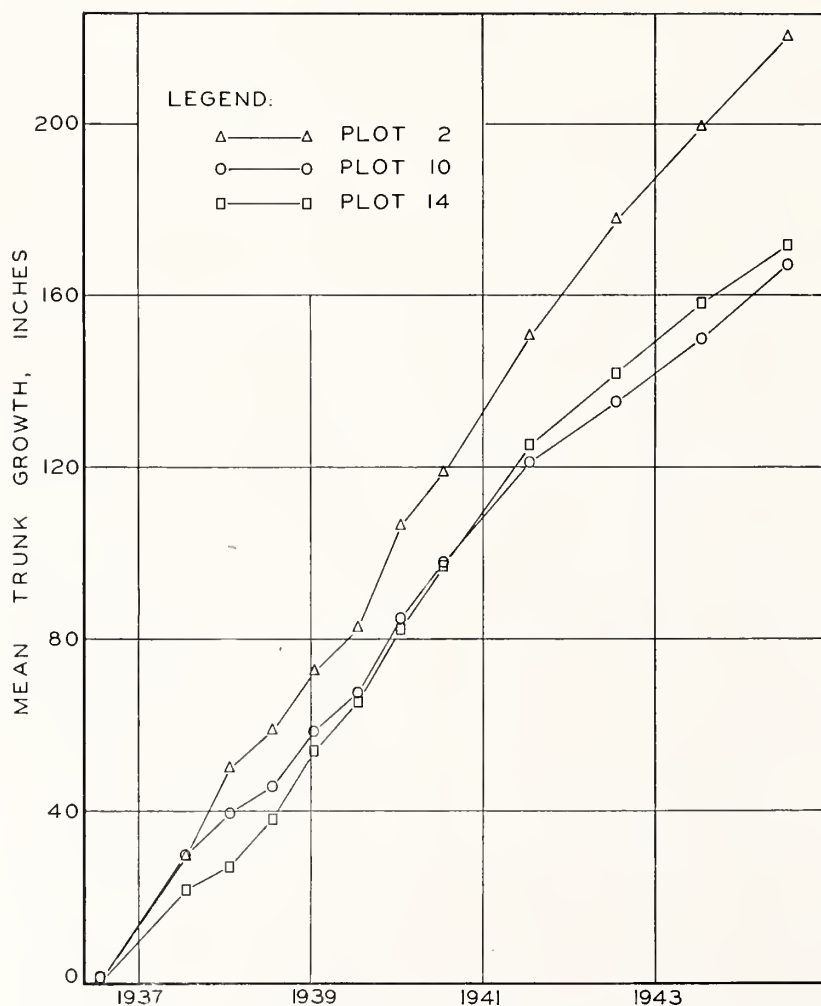


Fig. 3.—Curves representing the mean trunk growth (elongation) of Deglet Noor date palms in plots of the Arkell date garden fertilizer experiment, June 13, 1936, to June 15, 1944. The slopes of growth curves of palms in the remaining eleven plots were intermediate to those of the curves shown here.

The level of soil fertility in the Arkell fertilizer plots was not so high, however, that the palms failed to respond to additional fertilization. The records of fruit yield and trunk growth indicated a marked response to certain experimental treatments. Based on the average performance of palms in the four control plots, this response during the period 1939-1942 amounted to about 46 pounds of fruit (plot 7) and 6 inches of trunk elongation (plot 11) per palm per year. The difference in gross return was approximately \$5.60 per palm (plot 7) per year.

The response of the palms in plots 3 and 11 to treatment with ammonium sulfate alone was nearly the same as that of the palms in plots 2 and 7 to treatment with manure, ammonium sulfate, potassium sulfate, and triple superphosphate. Since these two treatments supplied about equal amounts of nitrogen, these results are thought to indicate that increased crop yield and trunk growth were due mostly to the addition of nitrogen. The effects of potassium sulfate and of triple superphosphate were not so evident. In view of the comparatively high crop yield and rapid trunk growth of palms in pretreated control plot 4, the data are not considered to be sufficiently critical to indicate whether or not the additions of potassium and phosphorus had any significant effect. It is generally believed, however, that for date culture the soil in the Arkell plots was already supplied with ample amounts of these elements in available form. There is also little or no experimental evidence that a response was obtained from the application of organic matter to this soil.

The mean yields of the experimental plots for the period 1939-1942 were below those for the year 1942, and considerably below the yields for the year 1944 (see table 4). This period, during which the experimental palms were ten to thirteen years of age, was marked by rapid vegetative growth and increasing yields. Maximum yields were probably not attained before 1944, when the palms were fifteen years of age.

Since this fertilizer experiment had been organized with the hope of increasing the quantity and improving the quality of dates in the Arkell orchard, it seemed logical to base the results on weights and grade separations of fruit in the packing house. In the course of the experiment, it became evident that the records from the packing house were not so useful as had been expected. A rather large error was introduced in the yield records because the spoiled or fallen dates remaining under the palms were not included. In fact, prior to 1944, the cull dates were intentionally discarded to avoid the payment of handling charges in the packing house. The standards for grade separations in the packing house tended to change from year to year according to the relative excellence of the crop. Fruit grading (28) was based principally on size, moisture content, and freedom from blemish. Chemical analyses (27) indicated that the fertilizer treatments had not affected the percentage composition of the dates: that dates from one plot were essentially like those from any other. We concluded, therefore, that under the conditions of this experiment the packing-house records of weights were in-

complete, and that the grade separations were affected more by weather and by fruit-bunch management than by fertilizer treatment.

At the beginning of the experiment, each palm was allowed to produce as much fruit as cultural conditions permitted. Such a system might have been easily followed in the case of an annual crop like wheat, where all the leaves and fruit (grain) are retained, but it proved to be very difficult with dates because of leaf-pruning and fruit-thinning practices. In attempting to obtain maximum yields, we were confronted with the problem of alternate bearing (19). Our present method of balancing the fruit crop with the green-leaf area (see "Materials and Methods") involves an estimation of the ability of a palm to produce fruit without alternate bearing. This regulated fruit-bearing ability of a palm is definitely related to vigor and to the kind of responses (growth rate, size and color of top, size of fruitstalks, number of flowers, etc.) that a palm makes to its environment. The regulated fruit-bearing ability of a palm may be defined as the maximum number of dates that can be successfully matured in one crop without producing alternate bearing. This quantitative method is proposed as a proper "yardstick" for measuring the response of a date palm to soil fertility. It is not subject to the objections which apply to the use of packing-house records, as previously discussed.

Methods of soil fertilization, leaf pruning, and fruit-bunch management, similar to those employed in plots 1 and 8, were followed in the Arkell orchard, exclusive of the experimental plots. The orchard there-

TABLE 4.—Yield of Deglet Noor Dates in the Arkell Orchard, Exclusive of Test Plots, 1943 and 1944.

PALMS PLANTED		YIELD (pounds)			
		—1943—		—1944—	
Year	Number	Mean Per Palm	Total	Mean Per Palm	Total
Edible Dates (grades A-D)					
1929	232	300.0*	69,600	381.6*	88,532
1931	752	267.0*	195,500	333.3*	250,675
1933	125	117.5*	14,695	240.0*	30,000
1935	52	100.0*	5,200	150.0*	7,800
1936	193	70.0*	13,510	100.0*	19,300
1938	35	40.0*	1,400	60.0*	2,100
Total ar mean	1,389	216.0	299,905†	286.8	398,407†
Nonedible Dates (culls)					
Harvested with crop		35.9	49,846	31.3	43,445
Salvaged in orchard		0.0	0	45.8	63,620
Total ar mean		35.9	49,846†	77.1	107,065†
Grand total ar mean		251.9	349,751†	363.9	505,472†

* Estimated value based on experience in Arkell orchard.

† Actual weight.

fore demonstrated the kind of results that might be expected elsewhere under similar conditions. The 1,389 Deglet Noor palms in this orchard, exclusive of the test plots, represented six different planting dates, from 1929 to 1938, inclusive (table 4). The palms planted in 1929 and 1931 received manure at the rate of 500 pounds each, annually, from 1934 to 1939. Beginning in 1940, every palm seven years of age or over received annually 400 pounds of manure and 10 pounds of ammonium sulfate. In 1943 and subsequent years, each of the 1,389 palms received annually 400 pounds of manure and 20 pounds of ammonium sulfate. Cover crops of Hubam clover were also grown in certain blocks prior to 1943. The orchard, irrigated at intervals of 10 to 30 days, was watered almost entirely by the deep well (5-6-22c), and in 1943 and 1944 the total annual application was about 17 acre-feet of water per acre. On the basis of experience in the Arkell orchard and of the actual weights of marketed fruit, the mean yields per palm were estimated for the crops of 1943 and 1944 (table 4). An average five-year-old palm was thought to yield 40 pounds of edible dates, and an average fifteen-year-old palm, 381.6 pounds. The dates marketed in 1944 from the entire orchard amounted to 286.8 pounds of edible fruit and 77.1 pounds of culls per palm. Since the mean yield of all palms six to fifteen years of age was 363.9 pounds, it is probable that each of the oldest palms yielded more than 450 pounds. Despite this remarkable performance, no sizeable reduction in number of fruits retained per palm was observed in 1945.

Summary

A cooperative fertilizer experiment was undertaken in 1935 in an orchard of six-year-old Deglet Noor palms eight miles west of Indio, California. The fourteen test plots included two plots for each of five fertilizer treatments, and two plots for each of two controls, pretreated and untreated. The irrigation water supplied about 5.15 pounds of nitrate per palm per year.

Although the weights and grade separations of fruit delivered to the packing house were recorded each year from 1935 to 1943, only those for the crops of 1939 to 1942, inclusive, were judged worthy of publication. During that period, the highest mean yields were obtained in plots 2 and 7, where fertilizer applications had consisted of manure (400 pounds), ammonium sulfate (20 pounds), potassium sulfate (30 pounds), and triple superphosphate (20 pounds) per palm per year. Mean yields nearly as high

were obtained in plots 3 and 11, where each palm had received 40 pounds of ammonium sulfate annually. The lowest mean yields were obtained in untreated control plots 13 and 14. The mean gross return per palm per year ranged from \$21.02 in plot 7 (244.9 pounds of dates) to only \$14.14 in plot 13 (193.3 pounds of dates). The mean annual trunk growth (elongation) ranged from 31.14 inches in plot 11 to 26.0 inches in plot 14.

Despite the original high level of soil fertility in the experimental plots, and the addition of nitrate by the irrigation water, the response of the palms to additional fertilizer (on the basis of comparison with the average performance of palms in the four control plots, 1939-1942) amounted to about 46 pounds of fruit (approximately \$5.60 in gross return) and 6 inches of trunk elongation per palm per year. This response is thought to be mostly due to the addition of nitrogen. The data are not considered to be sufficiently critical to indicate whether or not the additions of potassium and phosphorus had any significant effect. There is also little or no experimental evidence that a response was obtained from the application of organic matter to this soil.

A method of fruit thinning was developed for the purpose of balancing the fruit crop with green-leaf area, and of obtaining maximum yields without alternate bearing. The fruit-bearing ability of a palm, when regulated by this method of fruit thinning, is thought to be definitely related to vigor and to the kind of responses that a palm makes to its environment. The regulated fruit-bearing ability of a palm, or the maximum number of dates that can be successfully matured by a palm in one crop without causing alternate bearing, is proposed as a proper "yardstick" for measuring the response of a date palm to soil fertility. The use of packing-house records was objectionable for this purpose because the records of weight were incomplete and the grade separations were apparently affected more by weather and by fruit-bunch management than by soil fertilizer treatment.

The adoption for the Arkell orchard (exclusive of the experimental plots) of methods of soil fertilization (manure, 400 pounds; ammonium sulfate, 20 pounds), leaf pruning, and fruit-bunch management similar to those employed in plots 1 and 8 resulted, in 1944, in a mean yield (including culls) of 363.9 pounds of dates per palm. Since this value included palms ranging in age from six to fifteen years, it is probable that each of the oldest palms yielded more than

450 pounds. In 1945 there was no sizeable reduction in the number of fruits retained per palm.

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THE BEETLE INFESTATION IN DATES

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Loss in the date gardens and the packing houses from beetle-infested dates has been recognized by the date industry for a long time. Ten or fifteen years ago, when the industry was smaller and the infestation lighter, the loss was endured without much complaint. During the last six or seven years the losses have been increasing and have now reached serious proportions. This has been caused, in part at least, by changed harvesting methods made necessary by a shortage of labor. In 1945, a year of abnormally high humidity which encouraged the development of molds and souring in association with beetle injury, the losses were excessive. As a result, representatives of the industry called on the University of California for help, and the University of California in turn solicited the cooperation of the Bureau of Entomology and Plant Quarantine. By mid-November cooperative work between the Bureau of Entomology and Plant Quarantine, the Government Date Garden, and the Citrus Experiment Station, University of California, was under way in an effort to determine the nature of the problem and what could be done about it. Since the beetles are usually associated with materials that are sour and moldy, the problem involves a study of their relation to souring and molding as well as of the beetles themselves. This makes research by both entomologists and plant pathologists desirable. The cooperation between the Bureau and the Station at Riverside offers an opportunity for entomologists and pathologists to work together.

The collections at the Fresno laboratory of the Bureau contain at least four species of beetles which have been taken on dates in the Coachella Valley. All of these are abundant on dates, all are closely related members of the same family of beetles (the Nitidulidae), and all probably have similar habits. Two species appear to predominate. One is the black beetle with buff-colored spots on its wing covers, *Carpophilus hemipterus* (L.), which is properly known as the dried-fruit beetle. The other is brown and is probably the corn sap beetle, *Carpophilus dimidiatus* (F.). In the early 1930's mass collections of beetles from dates were black, owing to the abundance

of the dried-fruit beetle. Similar collections in 1945 were brownish, because of the predominance of the brown beetles.

The activities of the beetles in the date gardens may be more easily understood if some of the information on the dried-fruit beetle, secured at Fresno, is reviewed.

The life cycle of the dried-fruit beetle, from egg to adult, requires about three weeks at 80°F., in the laboratory. This is about the length of the period of development in ripening figs in the orchard in August. The eggs hatch in one to five days, the larvae become full grown in eight to 23 days, and the pupae transform into adults in five to 12 days. The averages for these periods are 2, 11, and 8 days. The temperature controls the rate of larval growth if the food supply is adequate. However, neither the most favorable temperature for larval growth nor the maximum and minimum temperatures which stop development have been determined for this insect.

When full grown the larvae leave their food and enter the soil for pupation. After a period they emerge from the soil as adults to repeat the cycle. In the field the beetles breed and feed on any material which contains enough sugar to permit fermentation. The adults are long-lived insects and have been kept alive in the laboratory more than a year. Males have been observed to live from 59 to 159 days and females from 30 to 143 days. Average lengths of life have been recorded as 129 days for males and 114 days for females. The females are prolific egg producers, one group having been observed to lay an average of 572 eggs each. Separation of generations in the field is impossible, since the beetles feed and breed throughout the year and the females lay eggs during most of their lives. As a result more than one generation of adults may be present at one time, and larvae and pupae may be found in the soil and adults on the surface at almost any time.

The beetles are strong and active in flight. Flights of $2\frac{1}{2}$ miles in four days have been traced by liberating and recovering marked individuals. Flight occurs during day-

light hours when the temperature is above 65°F. The activity increases with the temperature and is greatest between 85° and 100°F., although at the same temperature the beetles may be less active when the sun is high than when it is lower.

Larvae of the dried-fruit beetle can withstand long periods under water. Submersions for 31 hours at 80°, 55 hours at 70°, and 126 hours at 40°F. are necessary to effect 100 percent mortality.

During the past winter a study has been made of the biology of the beetles in the date gardens, and a start has been made on the development of control measures. Unfortunately, harvest was well under way before the work was started and the opportunity to try control measures has been limited. However, observations begun in November have already given considerable information. This is summarized in the following paragraphs.

Estimates by various people in the industry set the 1945 crop loss at from 50 to 75 percent, depending upon the variety. Our own estimate in a Deglet Noor garden on the valley floor indicated a loss of \$945 per acre. About half of the waste fruit examined was infested with beetles, ranging from 78 percent of the dates on the ground immediately before the first picking to 24 percent of those discarded during the second picking. Much of the fruit, both infested and uninfested, was moldy.

It was found that when full-grown larvae left the dates they entered the soil to pupate and that they stopped burrowing soon after entering moist soil. Only an occasional larva was found below the 12-inch level, most of them were above eight inches, and, where the soil was moist to the surface, all were in the upper four inches. Unless the fruit on the ground had been disturbed by cultivation, the larvae were found in the areas under the bunches of dates, that is, within five or six feet of the palm trunks. Apparently they did not wander far from the fallen fruit before going into the soil.

Information about the development of larvae and pupae during the winter months has been obtained by periodical examinations of the soil. Larvae continued to enter the

soil and to pupate at least until the middle of December. There was little activity in February. In March activity was resumed, and freshly transformed adults which had not left the soil were found. By mid-March the larvae and pupae in the soil were developing steadily and adults on the surface were actively breeding in waste dates.

Variations in development due to different methods of handling waste fruit were found. In one young orchard where the dates remained on the surface and were warmed each sunny day, larvae continued to develop and to enter the soil all winter. In an older garden where the fruit was disked into the shaded soil twice during the harvest, the larvae developed slowly and remained small throughout the winter. This garden provided a good demonstration of the fact that burying infested dates will not eliminate an infestation but merely delay its development.

The relation of waste fruit to the beetle infestation in the soil was shown repeatedly during the examinations. When samples were taken where there was an abundance of waste dates, larvae and pupae were plentiful. When the fruit was scarce, the number of insects found was small. If no dates were present, it was hard to find insects.

In the course of the soil examinations it was observed that irrigation had an effect on the abundance of larvae and pupae. In one garden no living insects could be found in soil which had been flooded for 10 days. However, insects in the levees were not affected by the water. In a second garden, irrigated by the basin system, larvae and pupae appeared to be thriving after three winter irrigations of 48 hours each. No indication of control was observed in gardens where the water was distributed in furrows. These observations, as well as the submer-sion tests previously mentioned, in-

dicating that a change in procedure would be necessary if it should be found practical to use irrigation water to reduce the beetle population.

It is possible that chemical control may be used to attack the infestation at at least two points—the larvae and pupae in the soil and the adults on the fruit. The work was started too late for direct control measures to be applied against the adults on the fruit in 1945. However, preliminary to the use of soil fumigants for killing the immature forms in the soil, tree-tolerance plots have been set up at the Government Date Garden in which light, standard commercial, heavy, and excessive dosages of ethylene dibromide, D-D, ethylene dichloride, and benzene hexachloride are under test. Reaction of the palms to the applications is still under observation. The infestation under these palms was not heavy enough to give satisfactory figures on insect control.

UTILIZATION OF UNPOLLINATED DEGLET NOOR DATES

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The 1945 crop of Deglet Noor dates in the Coachella Valley was characterized by an abnormally high percentage of unpollinated dates. This situation was widespread in the valley although the amount of unpollinated fruit varied materially among the gardens, some being nearly normal in this respect. The possible reasons for the poor pollinization have been discussed by Reuther (1).

Normally it has not generally been considered worth while to try to salvage the unpollinated portion of the date crop, but the large tonnage last year made it very desirable for the growers to make an effort to obtain some returns from it, especially in view of the heavy loss sustained in the regular crop as a result of the early rains and prolonged periods of high humidity.

No exact information has been available as to the developmental composition of unpollinated Deglet Noor dates, although a total sugar content of 78 percent was found in ripe unpollinated Deglet Noor dates picked on January 27, 1943. It is obvious to any observer in the gardens that the unpollinated dates are far behind the normal pollinated fruits in development. It is also obvious that the lag in development is greater in bunches heavily loaded with unpollinated fruits than where relatively few fruits remain. Other things being equal, one can generally expect the unpollinated dates to develop early in gardens in which the normal crop develops early, but this relation does not necessarily hold. Some indication of the lag in development of unpollinated dates as compared with normal, pollinated dates is given in table 1. The comparison is based on total sugar content, and is related to the devel-

Table 2. Total sugar content of unpollinated Deglet Noor dates, expressed as percentage of dry weight.

Garden	Day of Picking 1945-46	Maturity	Field Run Percent	Ripened Satisfactorily Percent	Foiled to Ripen Percent
A	October 16	Kholol	....	....	62
A	October 25	"	60	75	58
B	November 9	"	70	70	61
C	November 27	"	....	....	54
D	January 4	"	....	75	65
E	January 4	Kimri	....	....	55
F	January 22	Kholol	....	....	43
B	November 9	Portly ripe	....	74	....
C	January 4	"	....	79	....
B	November 9	Ripe	....	74	....

opment of normal dates in a good garden in 1938. The composition of this and other gardens during entire growing seasons is available in a bulletin of the U. S. Department of Agriculture (2). The development of the unpollinated dates appears to be two to three months, and in one instance (garden F) was as much as six months, behind that of the regular crop. It is clear, therefore, that the unpollinated dates must be thought of as a second crop, distinct from the regular one.

The total sugar content of unpollinated Deglet Noor dates from various gardens is given in table 2.

The khalal dates that failed to ripen were appreciably lower in total sugar content than those that could be ripened. As was to be expected, the dates with the higher sugar content had a better flavor after ripening than those with less sugar. Only those fruits in which the tannin precipitated out of solution were considered to have ripened satisfactorily. These often contained rather tough fibers next to the seed cavity, making them undesirable to be used as whole dates, but these fibers can be broken up by adequate

grinding so as to make the dates satisfactory for use in making confections or for cooking.

The moisture content of immature unpollinated dates may be very high. The values for a few lots are given in Table 3. Separation on the basis of ability to ripen was not possible in the determination of moisture and only field-run lots were analyzed. However, about 90 percent of the khalal fruits picked from garden B could be ripened satisfactorily, and very few from either lot from garden A or the lot from garden C. From these and other results it appears that it would be undesirable to attempt to ripen khalal Deglet Noor dates with a moisture content much in excess of 50 percent.

Dates picked with a high moisture content shrink greatly during ripening and drying. The heavy shrinkage results in a high picking cost per pound pack out, increases the amount of packing house space, fuel, and labor required in preparing the dates for the market, and increases the loss from spoilage during handling. The percentage loss in weight sustained in bringing the moisture content down to a safe value is indicated in Figure 1. The lines are drawn to show the loss when dates of any given initial moisture content from 25 to 75 percent are dried down to 20, 23, 25, and 27 percent. This figure demonstrates the fact that even if an entirely acceptable product can be made from very immature dates with a high moisture content, the percentage pack out will be so small as to make the practice of questionable value. The values shown in this figure apply to pollinated as well as to un-

Table 1. Delay in the development of unpollinated as compared with that of pollinated Deglet Noor dates; based on total sugar content as percentage of dry weight.

KHALAL UNPOLLINATED DATES		Approximate Time of Comparable Composition for Pollinated Fruits
Garden	Day of Picking	
A	October 16	August 20
A	October 25	August 15
B	November 9	September 1
C	November 27	August 10
D	January 4	September 25
E	January 4	August 10
E	January 22	July 25

Table 3. Moisture content of unpollinated Deglet Noor dates, expressed as percentage of fresh weight.

Garden	Date of Picking 1945-46	Maturity	Field Run
A	October 16	Khalal	68
A	October 25	"	69
B	November 9	"	52
C	November 27	"	74
E	January 4	Kimri	64
F	January 22	Khalal	75
B	November 9	Partly ripe	42
B	November 9	Ripe	34

pollinated dates, but only the flesh is considered, no allowance being made for the seeds.

The decision as to whether or not to pick dates that are largely in the khalal stage must be made on the basis of several factors. The packing houses must be able to start the ripening and drying processes immediately after the dates are picked or the loss from mold will be very high. If packing house facilities are not immediately available the dates should be put into zero storage without delay; ordinary cold storage at a temperature near 32°F. is not adequate. This practice

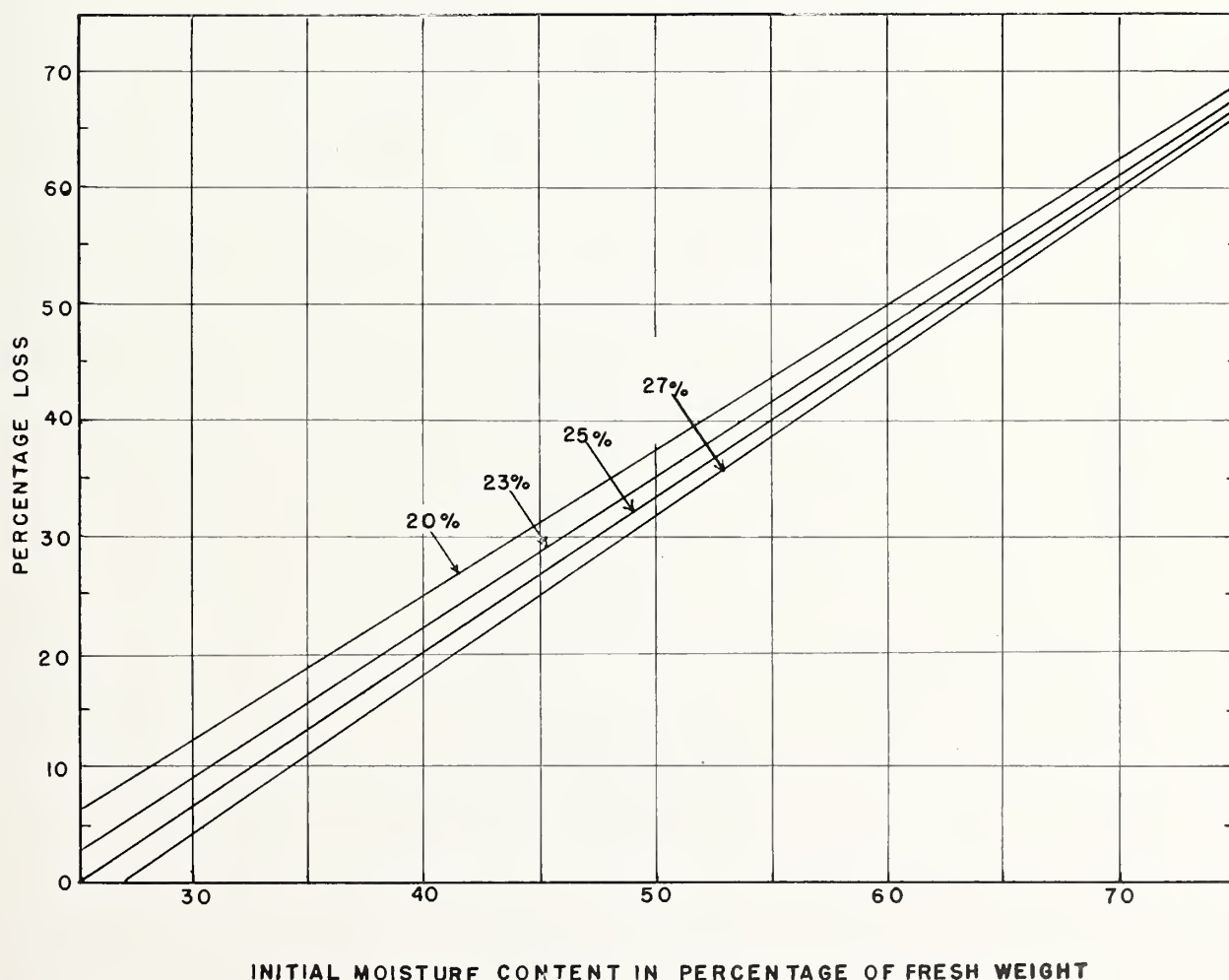
is not recommended at present because of the high cost resulting from the heavy shrinkage sustained in ripening; but the procedure given below provides a way of handling these dates if the grower should find it impossible or undesirable to allow the dates to remain on the palms until they become more mature. Dates that are left on the palms continue to accumulate sugar and other solids until they begin to ripen, so by allowing them to remain on the palms, not only is the percentage pack out increased but the actual tonnage available for sale is increased. In this connection

the possibility of rain damage during the winter months must be considered.

Method of Ripening

Immature dates trayed for ripening and drying must be spread in a thin layer on well separated mesh-bottom trays in a reasonably well-sealed room with a well-distributed positive air circulation. By this arrangement the dates will be warmed without delay, and during the latter part of the treatment they will be dried uniformly. The temperature should be maintained at 125° to 135°F. and the humidity must be kept high during the first day or two until ripening is well under way, otherwise the tannin will not be precipitated satisfactorily. No moisture need be added since the dates provide an adequate humidity if the room is reasonably well filled and is of tight construction. After one or two days of ripening, depending upon the maturity of the dates, the humidity and temperature may be lowered somewhat, although the temperature needs to be high as long as four days.

Figure 1. Percentage loss in weight when the moisture content is reduced from the initial value to a final value of 20, 23, 25, and 27 percent.



Khalal dates from garden B that were held in zero storage from November 13 to February 13 ripened after removal from cold storage. The exposure to a low temperature seemed to hasten ripening after removal and made ripening more uniform than that in comparable dates that had not been subjected to low temperatures. Ninety percent of these dates ripened satisfactorily.

Khalal unpollinated dates ripened by the above procedure are suitable for use in maceration. The product may be blended with the macerated product of naturally ripened dates to make an acceptable mixture for use in cooking and making confec-

tions. These dates are not suitable for marketing as whole fruit.

Summary

Immature unpollinated Deglet Noor dates can be ripened by holding them two to four days at 125° to 135°F. in a high humidity, provided the moisture content at the time of picking is not much in excess of 50 percent. If the moisture content is higher, the heavy shrinkage and the high cost of processing make ripening of questionable value. Immature dates that can not be handled immediately after picking must be held in zero storage to avoid mold damage. Ripening after re-

moval is hastened by this low temperature treatment. In the absence of rain damage, the most profitable practice is to allow the dates to remain on the palms during the winter months, at least until they have started to ripen. Artificially ripened unpollinated dates are suitable for use in date products but not as whole fruit.

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MECHANICAL INNOVATIONS FOR BETTER HANDLING OF DATE PALMS

By Leonhardt Swingle and A. E. Swindler

The saving or better utilization of labor has been a most important problem to all date growers the past few years and promises to continue that way for some time to come and in the operation of the Cook Date Garden west of Indio, Mr. A. E. Swindler has developed several machines or methods which it was thought would be of interest to all date growers. These are; first, the use of a tractor in cutting offshoots; second, a leaf grinder and last but not least, a picking platform for the better and more economical care of tall palms. These will be described briefly and then there will be some pictures showing them in operation. Mr. Swindler will endeavor to answer any questions you may ask at the end of the program.

A little over a year ago a number of date growers visited date gardens in Imperial and Yuma Valleys and at the George Hickcox ranch at Westmoreland and saw his arrangement to cut Saïdy offshoots with a tractor. When we later found ourselves with some 5000 large offshoots to cut in a short time, we thought of George Hickcox and his tractor and chisel and worked out a method by which we cut these shoots easily and quickly. Our method was as follows, just how it differs from that of George Hickcox I cannot say:

The chisel is 10 inches wide, 16 inches long and $\frac{3}{4}$ -inch thick, the handle a 2" bar. A piece of steel tubing that will slip over this 2" bar slides over the bar and has a ring welded in one end for a tractor hitch. A shoulder is raised on the bar so the tube will slip about 2 feet on the bar before it strikes the shoulder. The total length of the handle is 10 feet. The tractor is backed and this tube slips down over the bar for a two feet start and then the whole weight of the tractor drives the chisel. This two feet start gives the tractor momentum and you can readily appreciate the power of the stroke. This chisel is naturally very heavy and is supported at about the center of gravity by a tripod arrangement from the back of the tractor which is of great assistance in handling the chisel. The bar and sleeve are also fastened so that after the tractor has moved back two feet the full weight of the tractor is used to pull the chisel out of the cut. One man drives the tractor and one man places and supervises the driving of the chisel. Very little preliminary

digging is necessary and no side or extra roots need be cut nor does the palm need to be dug up to expose the offshoots. Bermuda sod can be readily cut through without bothersome digging and the cutter never has to make an extra or less advantageous cut just because the proper cut will be too hard either to drive in the chisel or remove it afterward.

We used a wheel tractor as a hitch higher gives a better chance to maneuver for a good stroke. We did not break the chisel once, much to our surprise and we cut some very large and difficult offshoots. On small offshoots and young palms, it would probably not be worth while but for large offshoots on old palms, we believe the cutting was quicker, easier on the palm and the cost much less.

Our leaf cutter has been used and operated for two years and does the work but should be heavier all around for most efficient work. Many leaf cutters have been built and used in the Valley but have not proved out because of either being too light or using a cutting edge that very promptly gets dull, requiring a shut down for sharpening. Our cutter is an old Bear Cat hammer mill mounted on a trailer and operated by an old Buick engine. The leaves are fed into a short apron that brings them into the hammers. It will handle a continuous load of about seven dry leaves but a whole arm load makes the engine stagger. The hammers are rectangular weighing about four pounds, revolve at about 2200 per minute, and the old Buick engine probably develops about 90 H.P. and is overloaded.

The leaves are ground into a fibrous material that is then afterward scattered by a fork and seems to disappear at the second discing. A great many growers have wanted a better way of getting rid of the old leaves than laboriously loading them on a wagon and hauling them to a sometimes distant vacant field where they can be burned. Also, there is unquestionably great fertilizer value in these leaves by means of the organic matter and minerals they contain.

The dry bases of date leaves are very hard indeed and we had to get the hardest material possible to use on the bolts that hold the hammers and for the hammers themselves. By actual test a pine 2x4 is easier to run through the cutter than an old

dry date leaf. We believe this machine to be right in principle, but it needs to be heavier all around so it can handle leaves as fast as they can be dumped in the hopper. This will require a more powerful but slower speed engine which does not seem to be available right now for any reasonable cost. The machine should be a community affair as one powerful machine that can grind up leaves as fast as two men can feed it will eat up all the leaves on one garden in short order and will be much more economical than a number of lighter machines.

Our picking platform for working around tall palms has attracted a great deal of attention and construction of four others on the same principle has followed. The original platform was built on an old truck that had served for moving houses and other heavy equipment and was equipped with a power take off and winch. The front wheels were widened and a telescoping tower was built in which the inner part can be raised or lowered as needed. The platform is large enough so that four palms can be serviced at once by means of eight swinging platforms attached at the corners so that two of these platforms are for one palm, one platform on each side of the palm. These swinging platforms are separately adjustable so that palms of varying heights can be taken care of, a most important feature.

The original platform takes care of 25 acres of Deglets that probably average over 35 feet in height. This is apparently about all the acreage one platform can conveniently handle, as in pollinating and picking the circuit of the garden must be made in reasonable time. In picking, eight people can work at once on the platform, picking four palms at a time and the ground man that drives the truck is plenty busy. We have had no trouble in getting Mexican nationals or women to pick on the high palms with this machine. Two years ago we paid the same picking rate on these high palms as the wage rate for low palms, and this item alone paid the cost of the machine. It has been very hard for us to get direct comparison of cost with the platform or without it, but indications are that the labor cost on high palms can be cut about half.

Three platforms are being built on this principle but are to be towed with a tractor instead of self-pro-

pelled. One of these three is in operation at the Crane Date Gardens where it has been inspected by many interested visitors. No hoist has been installed as the adjustable feature of the swinging platforms will take care of the palms for several years, and a hoist can be installed later when needed.

Another has been built with caterpillar treads and an old automobile engine so it is self-propelled and has a separate engine to hoist the inner section. There has been a great deal of trial and error in building these machines and there will undoubtedly be many improvements made in time to come, but the fundamental principles, a telescoping tower with adjustable swinging platform to handle four palms at once is, I believe, the only way to economically take care of our high palms.

When our palms started to bear, we picked from the ground and then

used step, track or extension ladders and we went along very well till the palms began to get up to 30 feet. Then we put permanent ladders on each palm or used a thirty or forty feet extension ladder and picking sling or harness. The picking harness or sling is one of the most useful tools that has been devised for a date grower, but many palms when they are 40 or more feet in the air have weaker leaves and a smaller crown and the harness begins to look dangerous to a man fastened to a seemingly weak leaf 40 feet above the ground. Then consider that to go from one palm to another when you are 40 feet in the air, it is 40 feet down to the ground, thirty feet to the next palm, and then forty feet up in the air again or 110 feet from palm to palm. You either pay your men a premium or he goes elsewhere and works nearer the ground. To pull the palm out after

they have borne for 20 years is a very uneconomical procedure it seems to me.

I have five acres set in 1919, 1920 and 1921. They have always had water and as good care as I knew how to give them. The tallest palms that have always been the best are now over 40 feet to the leaves and there is no sign whatsoever of any decline due to old age on any of the palms. The winds of 20 years have caused them all to lean more or less but in 1944 on 210 palms I picked 83,779 pounds of dates or just under 400 pounds per palm average. The average for the last 15 years is over 300 pounds per palm. The bloom this spring averages 18 good blooms, as heavy a bloom as they have ever had. I believe I can afford to pay a great deal for a machine to properly take care of these palms.

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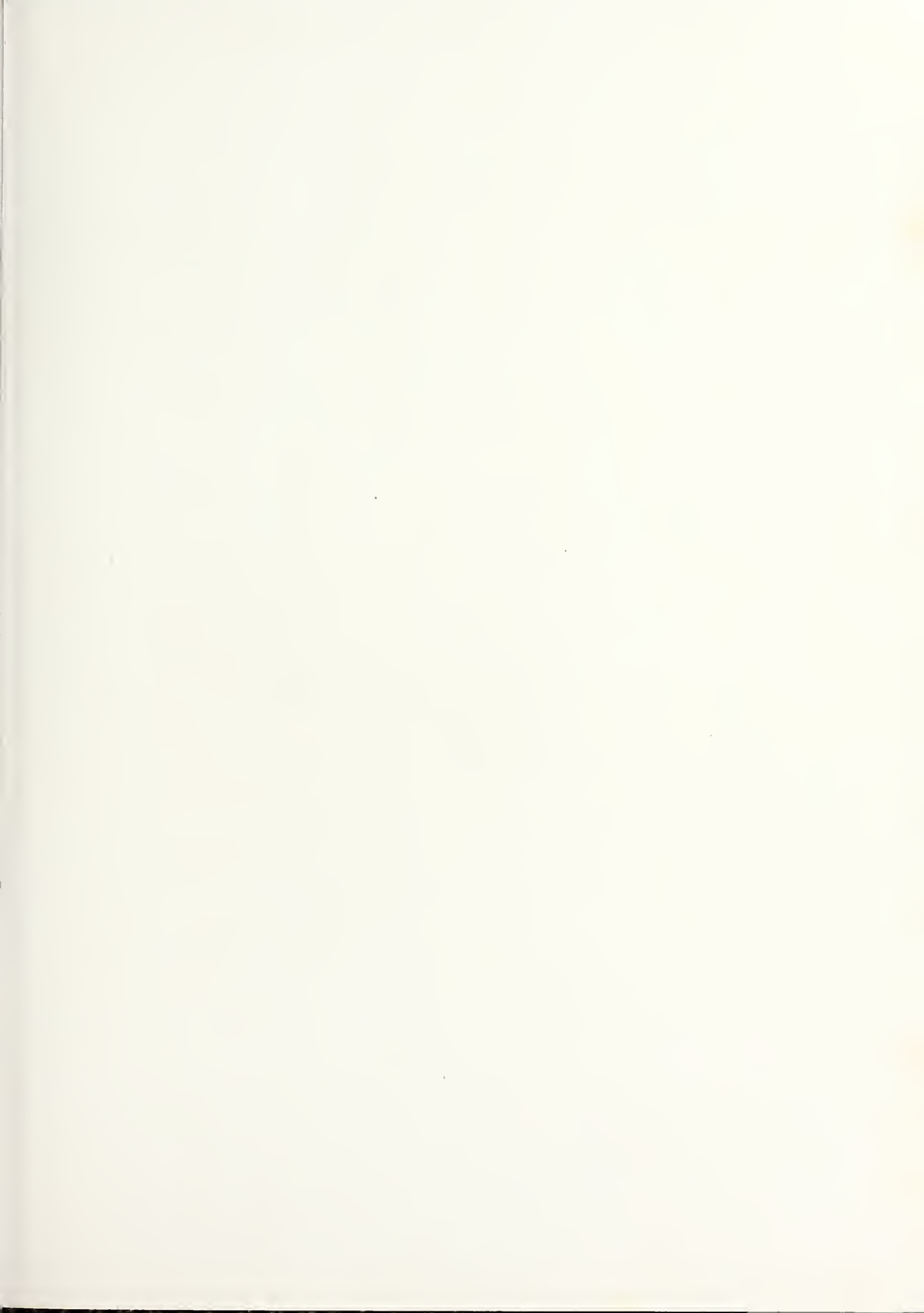
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